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HOFFMAN~~N~~ (Frederick Ludwig)

[Papers on dusty trades]

1. The mortality from consumption in dusty trades.
(Bull. Bureau of Labor, no. 79, November 1908)
2. Mortality from respiratory diseases in dusty trades
(inorganic dusts) (Bull. U.S. Bureau of Labor Statistics,
Whole no. 231, June 1918)
3. Preliminary report of Committee on mortality from
tuberculosis in dusty trades (U.S. Dept. of Labor, Working
Conditions Service, 1919)

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BULLETIN
OF THE
BUREAU OF LABOR.

No. 79. WASHINGTON. November, 1908.

THE MORTALITY FROM CONSUMPTION IN DUSTY TRADES.

BY FREDERICK L. HOFFMAN.

INTRODUCTION.

The importance of dust as a factor in occupation mortality has attracted the attention of every authority on occupation diseases from Ramazzini to Thomas Oliver. It requires no extended consideration to prove that human health is much influenced by the character of the air breathed and that its purity is a matter of very considerable sanitary and economic importance. Aside from the risk of exposure to so-called air-borne diseases, the pollution of the atmosphere by organic and inorganic dust is unquestionably the cause of a vast amount of ill-health and premature mortality, but chiefly among men and women engaged in the many indispensable trades and occupations that minister to human needs. The sanitary dangers of air contaminated by disease-breeding germs are probably not so serious as generally assumed, while the destructive effects of the dust-laden atmosphere of factories and workshops are a decidedly serious menace to health and life. While the investigations of Doctor McFadden and Mr. Lunt seem to prove the paucity of bacteria in very dusty air, the evidence otherwise available is entirely conclusive that the risk to disease infection is much greater indoors than out in the open, where sunlight, rain, and wind in combination go far to purify the atmosphere by destroying the bacterial life contained in minute particles of suspended matter. Apart, however, from the transmission of disease through a dust-contaminated atmosphere, dust in any form, when inhaled continuously and in considerable quantities, is prejudicial to health because of its inherent mechanical properties, destructive to the delicate membrane of the respiratory passages and the lungs. It has long been known that those who live most of their time out of doors have a decided advantage over those who, because of their employment, are compelled to spend their working hours inside the home, the office, the factory, or the workshop, and it is an accepted axiom of modern sanitary science that measures and methods for the prevention of dust are a first and preliminary essential consideration in rational methods of sanitary reform. All that sanitary science can suggest or that sanitary legislation can regulate and change should be done for humane reasons and as a matter of governmental concern to mitigate the needless hardships of those who suffer in health and life as the result of conditions over which they themselves have but a very limited control.

The importance of dust as a factor in occupation diseases has been emphasized by all who have written on the subject, but by no one more precisely and clearly than by Sir James Crichton-Browne, in his address on the Dust Problem, read at the Sanitary Congress held at Manchester, England, in 1902, from which the following is quoted:

> The mortality of the principal dust-producing occupations, compared with that of agriculturists, who live and work in what is practically dustless atmosphere, is excessive to a startling degree. It is not suggested that this excess is to be ascribed to dust alone, no doubt various factors contribute to it, but the facts that it is due mainly to respiratory diseases, that it is distributed amongst the several occupations pretty much in proportion to their dustiness, and that it has diminished in some instances where dust has been effectually dealt with, justify the conclusion that it is largely dust begotten.

Sir Crichton-Browne in continuation of his remarks pointed out that a detailed examination of the conditions of work in each of the 22 principal dusty trades brought out clearly the fact that the unhealthiness was born of or was primarily due to the dust inhaled by the workmen, and that there was always a well-defined relation between the death rate and the quantity and quality of dust present in the atmosphere. There is apparently no very material difference in the manner in which the different varieties of dust act upon the human organism, except where, in addition to mechanically injurious properties, the dust is of a poisonous character, which leads to diseases such as lead poisoning, phosphorous poisoning, anthrax poisoning, etc. Industrial mineral dust apparently acts with greater rapidity upon the lungs than organic dust, which is slower and more insidious in its operations, but in a general way follows similar lines. All varieties of dust, the immediate result of occupation, are, therefore, comprehended under the term of "industrial dust," which is specifically defined by Sir Crichton-Browne, as follows:

> I select this dust for my further remarks because it is readily recognized and defined, because its pernicious effects are well marked and indisputable, because it is to a large extent, if not entirely, pre-

ventable or removable, and because the efforts already made to prevent or remove it have been rewarded with conspicuous benefit. And I still further simplify and abbreviate what I have to say by restricting my observations to those varieties of it which are dust and nothing more, which are injurious by their physical properties and mechanical operations, and not as poisons to the systems, chemical destructives of the tissues, or bearers of bacterial invaders.

A similar but even more restricted limitation has been adopted for the present purpose, and only such occupations will be considered in detail in the following discussion as expose to the continuous and considerable inhalation of metallic, mineral, and vegetable fiber dust, and in which the evidence is at least fairly conclusive that the resulting disease liability and mortality from consumption and other respiratory diseases is above the average for occupied males generally.

Preliminary to a discussion in detail of the mortality from consumption in dusty trades it may prove of decided advantage to those who do not have access to the original sources of information to present a brief summary of qualified medical opinion regarding dust as a factor in occupation diseases and mortality. In a course of lectures on Unhealthy Trades, delivered before the Society of Arts, London, in 1876, Dr. B. W. Richardson([a]) placed injuries from the inhalation by the lungs of fine particles of solid matter, usually defined as dust, at the head of the causes responsible for industrial diseases, and from his discussion the following is quoted:

> The term "dusts," as I would here apply it, includes all those fine, solid particles which are thrown off from various substances in the processes of manufacture or treatment of articles in common use in daily life, such as earthenware utensils, knives, needles, or mechanical instruments, like files or saws; or ornamental things, such as ornaments of pearl, ivory, and turned wood; or articles that are worn, of silk, cotton, hemp, fur; or things that are used for food, such as flour; or for creating warmth, such as coal; or for using as a supposed luxury, such as tobacco and snuff. These are only a few illustrations; many others will naturally occur to those who think on the subject.
>
> The dusts which inflict injury are of varied quality, as will be seen from the brief sketch just given. They are also of varied effect in regard to the specific injuries which they produce. We may profitably study them divided into different groups, according to their physical characters, as follows:
>
> (*a*) Cutting dusts, formed of minute hard, crystallized particles which have sharp, cutting, and pointed edges. These dusts are composed of iron or steel, of stone, of sand or glass, of dried silicates in earthenware, of lime, of pearl.
>
> (*b*) Irritant dusts, derived from woods, from ivory, from textile fabrics, fluffs of wool, of silk, of cotton, of flax, and of hemp, from hair, from clay.
>
> (*c*) Inorganic poisonous dusts, derived from some poisonous chemical compounds used for coloring artistic products, or for preserving

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[a] Scientific American Supplements, Numbers 9, 10, 18, 19, and 22, dated, respectively, February 26, March 4, April 29, May 6, and May 27, 1876.

organic substances, such as furs. These dusts are charged with arsenical salts.

(*d*) Soluble saline dusts, derived from soluble crystalline substances used for dyeing purposes. The sulphate of iron, copperas, yields a dust of this class.

(*e*) Organic poisonous dusts, which are thrown off during the making up of tobacco into cigars and snuff. These dusts carry with them particles of the dried tobacco plant.

(*f*) Obstructive and irritating dusts composed of carbon, of fine particles of coal dust, of scrapings of carbon or of soot, of dust of rouge, and of flour.

Whatever may be the kind of dust to which the workman is subjected, to whichever of the above named he may be exposed, the primary cause of danger lies in the circumstance that the fine particles are borne by the air into the lungs. They pass, wafted by the air, through the mouth and nostrils into the windpipe; they pass along the bronchial tubes; in some instances they reach and traverse the bronchial passages which lie between the larger bronchial tubes and the minute air vesicles, or they even reach the air vesicles themselves.

An American authority on occupation diseases has referred to the subject at some length in an article contributed to Buck's Hygiene and Public Health, printed in 1879. This writer, Dr. Roger S. Tracy, for many years registrar of vital statistics of New York City and sanitary inspector of the board of health, makes the following statement with particular reference to the special form or type of disease resulting from the inhalation of metallic and mineral dusts:

The disease comes on very gradually, like the more slowly developed forms of phthisis pulmonalis, and its duration may be extended over four or five years. It begins with the cough of irritation, dry and hacking at first, with very scanty expectoration, whitish and stringy in character; there is no haemoptysis, but sometimes nausea and vomiting in the morning. Auscultation at this time reveals puerile respiration, with occasional slight râles. The expectoration gradually increases in amount and becomes reddish, and soon after this tinge appears there may be haemoptysis. There is dyspnœa on slight exertion, and dullness over the whole chest, with weak respiration and mucous râles. There is no fever, and the appetite and strength are still good. If work is abandoned at this time recovery is not only possible, but in most cases probable. If work is continued, the lung tissue begins to break down, and cavities form near the apices. Expectoration is very profuse, and there may be severe hemorrhages. There is general dullness on percussion, and the last traces of vesicular respiration give way to sibilant, large mucous and cavernous râles. Fever is continuous, with evening exacerbations, night sweats, emaciation, insomnia, and great dyspnœa, soon followed by death.

Very suggestive also are the observations and conclusions of Dr. John Syer Bristowe, F.R.S., who in an address on industrial diseases, read at the conference on sanitary subjects held in connection with the International Health Convention of 1884, discussed the effects of nonpoisonous irritants on the lungs, in part as follows:

> Occupations which habitually expose the workmen to the inhalation of abundant solid particles that are incapable of solution or removal by the animal tissues or secretions, in many cases induce chronic diseases of the lungs, which are known as the asthmas or consumptions of the several occupations referred to, and tend very materially to shorten life among those engaged in them. Workers in coal mines and in copper mines, grinders, millstone makers, and flax dressers are perhaps especially liable to suffer from such causes. It is marvelous how tolerant the bronchial tubes and lungs are of foreign particles which are drawn into them with the breath. Wherever smoke impregnates the atmosphere, as in London and other manufacturing towns, its particles are conveyed in greater or less abundance into the lungs; whence some are expelled with the expectoration, which presents, consequently, a slaty or black appearance, while some get absorbed, and becoming deposited in the tissue of the lungs, produce in them that black mottling which increases with advancing years, and is well known to pathologists. Yet, as a general rule, the soot-studded organs remain practically healthy, and no clinical evidences of pulmonary disease manifest themselves. The same remarks doubtless apply to the inhalation of the siliceous particles of ordinary dust. The effects are different, however, when such matters are inhaled in large excess. * * * The symptoms under which the sufferers labor have some resemblance to those of chronic phthisis, some to those of chronic bronchitis and emphysema, for either of which they may well be mistaken. They consist in gradually increasing shortness of breath, lividity of surface, feebleness of circulation, and cough, with more or less abundant expectoration; to which, at a later period, general dropsy and haemoptysis may be superadded. There is generally a total, or almost total, absence of fever. The only methods, so far as I know, by which the irritative diseases of the lungs, just considered, can be lessened or prevented, are by providing good ventilation, and (when possible) by adopting methods to prevent the diffusion of particles or dust in the atmosphere which the workmen have to breathe. It is obvious, too, that since the diseases are insidious in their progress, and increase in proportion as the inhaled particles accumulate, it would be well for persons who present early traces of them to seek at once some other kind of employment.

The most qualified and extended discussion of the entire subject of the inhalation of dust, its pathology and symptomatology, with special reference to dusty trades, is by Dr. J. T. Arlidge, who, in 1892, published a treatise on The Hygiene, Diseases, and Mortality of Occupations. "Few, indeed," he argued, "are the occupations in which dust is not given off," and "in none can it be absolutely harmless, for the lung tissue must be just so much the worse, and less efficient for its purpose, in proportion to its embarrassment by dust." And in continuation:

> What occurs to the ordinary citizen becomes magnified ten or a hundredfold to those engaged in dusty occupations, and more espe-

> cially where the dust itself possesses noxious properties. But unless dust has this latter quality, it is remarkable with what indifference its inhalation is treated by the majority of workmen. In one sense, indeed, it is unfortunate that it does not, for the most part, awaken attention by any immediate tangible consequences. Its disabling action is very slow, but it is ever progressive, and until it has already worked its baneful results upon the smaller bronchial tubes and air cells and caused difficulty of breathing, with cough and spitting, it is let pass as a matter of indifference—an inconvenience of the trade.

Arlidge called attention to the fact that bronchitis, asthma, and fibroid and tubercular consumption ranked foremost in the causes of British mortality, holding that without doubt these maladies were largely attributable to the inhalation of dust operating per se, or in conjunction with constitutional proclivities and insanitary surroundings. In further continuation he remarked that—

> Pathologists tell us of the presence of bacilli in tubercular disease, and favor the belief that these minute bodies are the cause of it. This notion may represent a whole truth or only a partial one; in my opinion, the latter. For I doubt if these bacilli actually develop phthisis unless there be some antecedent change in the vitality of the affected tissue; a change wrought by depressing causes connected with the mode of life, or with constitutional debility and inherited taint, or with the occupation followed; of which contributory factors two or more may cooperate. And assuredly the breathing of dust may be reckoned as one such of no light energy. In other words, I look upon a phthisical lung as one prepared for the germination and multiplication of bacilli, and not a primary product of those microscopic organisms, nor of the products of their organic existence.

The conclusions of Arlidge are summarized in the statement that "One practical lesson is to be gained by these considerations—namely, that persons predisposed to respiratory diseases and phthisis ought not to engage in dusty occupations."

More recently the entire subject of occupation diseases in their relation to workmen's compensation has been considered at length and in much detail by a British departmental committee appointed to consider the pressing and important question of workmen's compensation for industrial diseases. In its observations upon respiratory diseases, and in particular bronchitis, pneumonia, and phthisis, and their relation to occupation exposure, the committee concluded that—

> Pulmonary disease manifests itself in three kinds or forms—as ordinary tuberculous phthisis, acute or chronic; as "fibroid phthisis," and as a mixed form when a tuberculous process is ingrafted sooner or later upon the fibroid. Fibroid phthisis is always a slow disease. It consists in a chronic reactive inflammation around the many minute foci of dust inhalation, which by coalescence gradually invades large areas, impairing and strangling the proper lung tissues in corresponding measure. Again, a lung so impaired is very apt to har-

bor bacilli, especially the bacillus of tubercle, by the influence of which it may be still further destroyed. Thus both fibroid phthisis uncomplicated and fibroid phthisis with the supervention of tubercle are in their nature occupational disease.([a])

The committee, in its final report, describes the typical forms of fibroid phthisis as induced by the inhalation of industrial dust, holding that—

> The first symptom is a cough which insidiously, and for a while almost imperceptibly, becomes habitual. At first in the morning only, it gradually becomes more frequent during the day, and expectoration, nominal at the beginning, becomes more marked, though not profuse until the latter stages of the disease. Leaving out of account the more rapid progress of the disease in tin and gold miners, these symptoms of a negative phase of purely local damage may last for years—ten or fifteen or even more—without advancing to such a degree as to throw the workman out of employment or even to cause him serious inconvenience. At some period, however, rarely less than ten years and frequently more than twenty, of continuous employment, in a like imperceptible manner the breathing gets shorter and the patient finds himself less and less capable of exertion. Yet, even when the cough and dyspnœa have reached a considerable degree, there are no signs of fever, as is the case of pulmonary tuberculosis; the flesh does not fall and the muscles retain their strength and volume. Thus even at a period when the malady is fully established the general health may be but little impaired, and the patient may not be compelled to cease work. Herein fibroid phthisis presents a well-marked difference from pulmonary tuberculosis; and even if, as we have said, the disease becomes complicated with tubercle, yet the rate of progress may be determined rather by the character of the primary than of the secondary disease, though usually the supervention of tubercle hastens the sufferer into a more rapid consumption.([a])

The results of all these researches into an almost neglected field of preventive hygiene prove that occupation diseases, properly so called, demand the most thoroughly qualified and medical supervision of factories and workshops and the periodical medical examination and inspection of persons employed in recognized unhealthy trades. For, as the committee referred to points out, "If in the early stage of fibroid phthisis the workman leaves the dusty employment for work in agriculture or in other occupation in air free from irritating particles, the disease may be practically arrested; that is, although the part affected may proceed to obliteration, the disease would not extend to other parts of the lung, and the portion destroyed would be negligible as a factor of health and capacity."([b])

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[a] Report of the Departmental Committee on Compensation for Industrial Diseases, 1906, p. 13.

[b] Report of the Departmental Committee on Compensation for Industrial Diseases, 1906, p. 14.

The conclusion of this investigation, the most important official inquiry ever made into the subject of industrial diseases, fully warrants the view that while ordinary tuberculous phthisis can not be regarded as a disease specific to any occupation, fibroid phthisis in its latter stage, and when the history of the case is known, can be clearly distinguished from tuberculous phthisis, so that it may be regarded as an established fact that fibroid phthisis is a disease specific to the employment in certain trades, of which the committee mentions the following: Grinders, continuously using either grindstones or emery for the abrasion of metals, especially steel; potters engaged in certain processes; stone workers employed on certain kinds of stone, especially if not working in the open air; tin miners, in particular such as have previously been exposed to the exceedingly unhealthy conditions of the gold mines of the Transvaal; and ganister miners, including men employed in certain processes of ganister brick making. The committee did not arrive at final conclusions regarding persons employed in the slate industry, nor of employees in the working of asbestos, and many other recognized unhealthy trades, partly, no doubt, because of the limited scope of the inquiry and the paucity of conclusive statistical data. It is pointed out by the committee that it was not possible to separate the English death rates from fibroid phthisis from those of other diseases of the respiratory system, since medical men do not, as a rule, distinguish that disease when certifying the causes of death. It is clearly established by the results of the investigation that such a distinction should be made and that medical practitioners should qualify the death returns from tuberculosis in all cases where the death was the result of fibroid phthisis.

The committee, having arrived at the opinion that fibroid phthisis is a specific and distinguishable trade disease, concluded that employers might properly be required to pay compensation to their work people who contract it; but it did not, however, recommend the extension of the Workmen's Compensation Act to the disease for two reasons. The first was that owing to the long period of its development it would not be right to lay the whole burden on the employer under whom the workman had been serving during the twelve months prior to the incapacity. The other and more important reason was that for several years before the nature of the disease can be definitely diagnosed the patient may suffer from symptoms that while not distinctive are sufficient to prevent him from securing employment.

In the partly descriptive account of 42 occupations considered in detail in this article only the most general facts have been included to emphasize, as far as possible, the industrial processes productive of conditions more or less injurious to health in general and to the development of tuberculosis in particular. Authorities are referred to only as far as this has seemed necessary to clearly establish in the case of each trade or occupation considered the facts of a more or less excessive degree of consumption frequency aside from the statistical sources of information which form the basis of the subsequent conclusions, except in the case of a few employments for which neither general vital statistics nor insurance mortality experience are as yet available. The term "tuberculosis" is used in a very general sense, and as a rule limited to phthisis pulmonalis, or consumption, unless otherwise stated. All of the references to insurance mortality experience are limited to the mortality from phthisis pulmonalis and do not include other forms of tuberculosis or other forms of respiratory diseases unless specifically stated in the text.

STATISTICAL DATA AND METHOD OF DETERMINING THE DEGREE OF CONSUMPTION FREQUENCY.

The principal statistical data used in the present discussion are, first, the occupation returns by divisional periods of life of the United States census for 1900; second, the occupation mortality statistics of the Twelfth Census, published in 1904; third, the occupation mortality statistics of Rhode Island for the decade ending with 1906; fourth, the occupation mortality statistics published decennially as a supplement to the report of the Registrar-General of Births, Marriages, and Deaths for England and Wales for the two periods 1890–1892 and 1900–1902; fifth, the corresponding statistics for Scotland; and sixth, the industrial mortality statistics of the Prudential Insurance Company of America for the decade 1897 to 1906, published in connection with the company's exhibit of the mortality from consumption in dusty trades at the International Congress on Tuberculosis, held in Washington, D. C., in 1908, and presented in a discussion of the same subject before the American Association of Medical Examiners in September, 1907, and the Medical Society of the County of New York in December, 1907.

Four different statistical methods are available to determine with approximate accuracy the degree of consumption frequency in different trades. Absolute accuracy is not obtainable in investigations of this kind, nor is it necessary for the end in view.

The first method is to determine the numbers living at ages 65 or over in different trades, and to compare the same with the corresponding proportion for occupied males generally. This method is never conclusive by itself, but is useful in conjunction with the use of other statistical data. It is evident, of course, that other factors besides mortality determine the proportion of persons at work in different occupations at ages 65 or over, and the method, therefore, requires to be used with extreme caution.

The second method is to determine the true rate of mortality from all causes, or specific causes such as consumption, by ascertaining the number of deaths occurring in every thousand persons of any particular trade or industry exposed to the risk of death for a single year. This method is by far the most satisfactory, but it is seldom that accurate information is available regarding the living population, and estimates of the numbers exposed to risk are likely to be seriously misleading. The chance of error is increased by the method employed in the Twelfth Census, since the occupation classification of the census is probably not exactly the same as the occupation classification of the different boards of health throughout the country, where the original entries are made as to the occupation of decedent at the time of death.

The third method is to determine the proportion of deaths from a specified cause, such as consumption, occurring in the mortality from all causes, without reference to ages at death. This method is made necessary in the use of the Rhode Island statistics, which are not returned by divisional periods of life. The same is true also of the occupation mortality statistics of the United States census by specified causes, but when used with extreme caution the proportions thus determined are often extremely suggestive and quite often entirely conclusive.

The fourth method is known as the proportionate mortality figure, by which the proportion of deaths from any particular disease, such as consumption, is calculated as a percentage of the deaths from all causes occurring during specified periods of life. This method has been extensively employed in the present discussion, since otherwise the available industrial insurance mortality statistics could not have been utilized. It is, in a measure, the most satisfactory and determining of all the various methods referred to, since it determines with absolute accuracy the actual incidents or degree of consumption frequency at specified periods of life.

The industrial insurance mortality statistics are derived from the experience of a large and representative company, which has from time to time given publicity to the facts of its experience. The resulting proportionate mortality returns, however, indicate a specific mortality from consumption somewhat below the actual, since the experience is, to a certain extent, affected by medical selection. In other words, the proportionate mortality from consumption, or the true actual loss from the disease at specified periods of life, would have been somewhat higher if medical selection had not been made use of. In comparing this experience with the adopted standard for the registration area of the United States the comparison is, therefore, somewhat more favorable to the various trades and occupations considered than would have been the case if the returns could have been derived from the registration records of the different States and cities comprehending the experience of the company referred to.

The proportionate mortality figure may be briefly explained as follows: At ages 25 to 34, out of every 100 deaths from all causes in the registration area of the United States during the seven years ending 1906, 31.3 deaths were from consumption. The corresponding proportions of deaths in the industrial insurance mortality experience were 70.8 per cent for grinders, 66.7 per cent for compositors, 58.5 per cent for upholsterers, 52.9 per cent for potters, etc. The difference between the normal proportionate consumption mortality for the registration area as a whole and the corresponding proportionate mortality from consumption in the different occupations considered in detail, measure approximately the health-injurious circumstances of the different employments.

OCCUPATION CLASSIFICATION OF DUSTY TRADES.

The following occupation grouping has been adopted to emphasize the dust hazard in principal occupations and to facilitate ready reference to the various employments considered in some detail in the subsequent discussion:

Group 1.—Exposure to metallic dust:

1. Grinders.
2. Polishers.
3. Tool and instrument makers.
4. Jewelers.
5. Gold leaf manufacture.
6. Brass workers.
7. Printers.
8. Compositors.
9. Pressmen.
10. Engravers.

Group 2.—Exposure to mineral dust:

11. Stone workers.
12. Marble workers.
13. Glass blowers.
14. Glass cutters.
15. Diamond cutters.
16. Potters.
17. Cement workers.
18. Plasterers.
19. Paper hangers.
20. Molders.
21. Core makers.
22. Lithographers.

Group 3.—Exposure to vegetable fiber dust:

23. Cotton ginning.

Group 3.—Exposure to vegetable fiber dust—Concluded.

24. Cotton textile manufacture.
25. Spinners.
26. Weavers.
27. Hosiery and knitting mills.
28. Lace making.
29. Flax and linen manufacture.
30. Hemp and cordage manufacture.
31. Manufacture of jute and jute goods.
32. Paper manufacture.
33. Cabinetmakers.
34. Wood turners and carvers.

Group 4.—Exposure to animal and mixed fiber dust:

35. Furriers and taxidermists.
36. Hatters.
37. Silk manufacture.
38. Woolen and worsted manufacture.
39. Carpet and rug manufacture.
40. Shoddy manufacture.
41. Rag industry.
42. Upholsterers and hair-mattress makers.

The grouping is necessarily a more or less arbitrary one since all occupations involve exposure to more than one particular kind of dust, but it is safe to assume that the predominating character of a particular dust exposure primarily determines the resulting departure of the consumption mortality from the normal for the general population. All the groupings of dusty trades which have been adopted by Hirt, Merkel, Arlidge, Oliver, and others have this limitation in common. Since no entirely conclusive investigation has been made to afford the material for a final and strictly scientific classification of dusty trades, the grouping adopted will serve at least the purpose of a convenient arrangement with a strict regard to the facts as they are known and understood at the present time.

OCCUPATIONS WITH EXPOSURE TO METALLIC DUST.

In the group of occupations exposing to a continuous and considerable inhalation of metallic dust resulting from industrial processes have been included for the present purpose the following representative employments: Grinders, polishers, tool and instrument makers, jewelers, gold-leaf manufacture, brass workers, printers, compositors, pressmen, and engravers. These occupations are all more or less subject to an excessive death rate from all causes, but in particular to a decided excess in the proportionate mortality from consumption, and in most cases also to a comparatively high degree of frequency in the occurrence of other respiratory diseases. The details of labor conditions, as far as they could be conveniently included in the following summary of observations regarding particular trades, appear to fully confirm the opinion that the degree of excess in consumption frequency is intimately related and in almost exact proportion to the degree of exposure to continuous and considerable inhalation of metallic dust.

GRINDERS.

The grinding trade includes a large variety of employments, of which metal grinding, by either the dry or wet process, is hygienically as well as industrially the most important. The grinding of metal involves exposure to decidedly health-injurious conditions, probably as much so if not more than in any other employment. Chiefly as the result of the inhalation of relatively large quantities of fine metallic dust, and not inconsiderable quantities of fine mineral dust, the mortality from consumption in this occupation is decidedly above the normal for occupied males generally. While the sanitary and other conditions injuriously affecting the health of metal grinders never have been so notoriously bad in the United States as in England or in continental Europe, the observed mortality of this occupation as carried on in this country fully warrants the most serious conclusions as to the health-injurious effects of this group of employments.

The mortality of metal grinders has been discussed by James H. Lloyd, M. D., in his treatise on "Diseases of occupations," included in the Twentieth Century Practice of Medicine, published in 1895. Lloyd, after calling attention to the well-known fact that the trade of the grinder is conspicuous above all others for the suffering that is entailed from the inhalation of metallic dust, describes in detail the different processes of grinding and their relation to health, from which the following is quoted:

> Grinding edge tools is of two kinds—wet and dry. The latter method is by far the more injurious, as, naturally, it raises far the greater amount of dust. For some tools both methods are used—the mixed method. The tools ground are scythes, saws, table knives, machine knives, various other kinds of edge tools, files, penknives, razors, scissors, forks, needles, etc. A great difference in their bad effects is observed among the branches of the trade according as the grinders use the wet or dry method and according to the tool ground. The smaller objects are far the most trying and exacting upon health. The worst of all branches are the fork grinding and needle grinding. This is because in grinding these small objects the workman is obliged to lean close over the stone and therefore inhales large quantities of the dust, and also because the dry grinding is used.
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> The dust raised by grinding is composed largely of minute bits of steel. According to Hall, 12 razor blades forged in the rough, which weigh 2 pounds and 4 ounces, lose 10 ounces in the process of grinding. This loss represents so much fine metallic dust, mingled of course with dust from the stone. This statement gives some idea of the immense amount of dust produced by dry grinding. According to Holland the concrete masses of this dust formed in needle grinding have almost the specific gravity of iron.

In discussing the symptoms of the diseases typical of grinders as the result of their employment, Lloyd points out further that—

> They are those of a slowly advancing bronchitis with asthma and sometimes with emphysema; later dilated bronchi with excavation are observed; then, consolidation, and breaking down of lung tissue occur as the terminal processes. The exact relationship of these processes to a tubercular infection in grinders is an interesting and important subject, which, of course, did not receive much light from the earlier writers. They endeavored, in fact, to draw distinctions between true "consumption" and grinder's "asthma," but the state of pathological knowledge in their day was not such as to permit them to do otherwise. It is quite evident from reading their reports of cases that they had to do with a disease that was essentially tubercular, but it would be interesting to have the exact relationship of this infection to the grinder's unwholesome occupation investigated by the methods of modern bacteriology. I do not know whether this has ever been done. There can be no doubt that the influence of the grinder's trade is that of a predisposing cause. The inhalation of the irritating particles of steel into the lungs causes a constant catarrhal bronchitis and pneumonitis, with increase of connective tissue; and this prepares the soil for a tubercular infection which characterizes the latter stages of the disease.

The most recent qualified discussion of the health-injurious circumstances of dry and wet grinding is by Oliver, who, in his Diseases of Occupation, goes fully into all the details concerning the trade, including a brief account of the corresponding conditions in the cutlery manufacture of Germany, at Solingen:

> So far as the two methods of grinding cutlery are concerned, the dry method is, from a health point of view, the more dangerous to the workers. The dust is dry, and is in the form of a very fine powder, which readily reaches the lungs owing to the attitude of the men when at work. Steel grinders sit astride the grinding stone on a saddle, and as they lean forward keeping close to their work, they can not but inhale some of the dust, which is a mixture of steel and stone. Forks and needles are generally ground by the dry method; knives, scissors, and razors by the wet. Some are ground by both methods, e. g., the backs of razors and scissors are ground by the dry method and the remainder of the blade by the wet. It was in 1865 that Dr. T. C. Hall, of Sheffield, drew attention to the high death rate of steel grinders from pulmonary phthisis. The average age at death of steel grinders was at this period only 29 years, but of late this has improved. Doctor Hall's statistics referred to dry grinding. In wet grinding the running stone passes through a thin layer of water in a trough below the stone, so that, as its surface is always kept wet, comparatively little dust is given off during the process of grinding; but while the atmosphere is clearer of dust, the floors and walls of the workshop are damp and cold. The grinding is carried on in rooms called "hulls," which are bounded by three blank walls; the windows are without glass. Where dry grinding is carried on there are fans, but these often prove ineffective. It is no uncommon thing to find men engaged in different processes in one large room, so that the dust which is generated affects not only the workman sitting at his own grinding stone, but the other inmates of the room as well. In Sheffield it has been ascertained that in every 1,000 deaths among steel grinders pulmonary phthisis is the cause of 345 and other respiratory diseases 295; that is, collectively, pulmonary diseases account for 64 per cent of the entire mortality, whereas among the adult population of the country generally phthisis accounts for 144 deaths per 1,000 and other respiratory diseases 182, or collectively 32.6 per cent. Steel grinders die comparatively young. Dr. Sinclair White, in Dangerous Trades, page 414, says that 458 grinders in every 1,000 die between the ages of 35 and 55, compared with 261 in every 1,000 of the entire male population of the country. Only 140 grinders out of every 1,000 reach the age of 55 and upward, whereas for every 1,000 of the adult male population 391 reach 55 years and upward. Sinclair White is of the opinion that phthisis is not so rife among steel grinders as formerly. In Doctor Hall's time the average age at death from phthisis was 29 years; at present it is 43.([a])

With reference to conditions in Germany and the remarkable improvement which has followed the introduction of sanitary precautions, rational methods of ventilation, and other means of dust prevention, Oliver holds:

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[a] Diseases of Occupation, Thomas Oliver, pp. 230, 231, London, 1908.

> In the town of Solingen and the neighborhood it is estimated that there are 29,000 persons employed in making cutlery. Here all sorts of steel goods are made—knives, forks, scissors, and swords. A good deal of the work is done by the people in their homes, and it is interesting to know that the home industry is rather encouraged by the local authority, which provides the men with gas and electric power. So prevalent is pulmonary consumption among the grinders in Solingen that it has attracted the attention of the Government Factory Department. In the ten years 1885–1895 72.5 per cent of the deaths among knife grinders in the Solingen district was due to phthisis, against 35.3 per cent for the rest of the population over 14 years of age, and an official examination showed that out of 1,250 grinders only 85 men were over 45 years of age. Doctor Shadwell speaks approvingly of the methods adopted in some of the Solingen factories to deal with the removal of dust. Oldendorf, in writing about the grinders at Solingen, states that 24.7 per cent reached 50 years of age and 3.3 per cent 70; that at Runsched 33.8 per cent reached 50 years and 8.0 per cent 70; while at Kronenberg the numbers were 32.9 and 8.7, respectively. The mean age at death of grinders employed in the dry methods was 39.4, of workers in iron 48.3, and of the rest of the male population 54.4 years. Taking all ages, the deaths from tuberculosis per 100 cases were for grinders 78.3, iron workers 59.0, other persons 46.0.(a)

A very interesting account of the mortality of cutlery grinders in Solingen was also included in the Report of the Chief Inspector of Factories and Workshops of England for 1906, from which an abstract is made to emphasize the sanitary and labor conditions necessary to reduce the mortality of grinders to a minimum:

> The atmosphere of Solingen is bright and clear. It is seldom that black smoke is seen escaping from the factory chimneys. This is largely the result of careful firing and the use of coal briquettes instead of ordinary coal, which avoids the use of slack coal. The day's actual work is nine hours; on Saturday work ceases at 5.30 p. m. The factories in Solingen are said to be marvels of order and cleanliness; the floors are of concrete and the air space for each worker must be at least 565 cubic feet. All the grinding stones are protected by guards. The walls of the workrooms are limewashed every year; the floors are swept every evening and damp-wiped once a week. The "rasing" of grindstones is never undertaken during working hours except under a stream of water or unless the stone is entirely inclosed in casing except at the working place of the rasing tool. The floors are kept clean and provision is made for the removal of the dust during grinding. Cutlery manufacture is recognized as a dangerous trade in Solingen, and in recent years considerable improvement has taken place in the means to prevent dust. In Solingen the grindstones and polishing wheels are run toward the worker; in Shef-

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(a) Diseases of Occupation, Thomas Oliver, p. 232.

field they are run away from the worker, so that the dust has an upward tendency and flies into the room.[a]

The subject is also considered in the Report of the Chief Inspector of Factories and Workshops for 1907, in which the rules or police regulations governing the trade at Solingen are republished in full. A remarkable improvement in the health of the workmen has followed the introduction of these rules.

The most conclusive mortality data of metal grinders are for Sheffield, England, and from the annual reports of the medical officer of health are tabulated the deaths of grinders occurring within the period 1889 to 1906, including 2,045 deaths from all causes, of which 837 were from consumption and 543 from respiratory diseases other than consumption. The data are given in tabular form below, by divisional periods of life, with the resulting mortality from consumption and other respiratory diseases at specified ages:

PROPORTIONATE MORTALITY FROM CONSUMPTION AND FROM OTHER RESPIRATORY DISEASES COMPARED WITH THAT FROM ALL CAUSES AMONG **GRINDERS**, IN SHEFFIELD, ENGLAND, 1889 TO 1906, BY AGE GROUPS.

[From annual reports of the Medical Officer of Health, Sheffield, England.]

Age at death.	Deaths from all causes.	Deaths from consumption.		Deaths from respiratory diseases other than consumption.	
		Number.	Per cent.	Number.	Per cent.
Under 25 years	85	36	42.4	20	23.5
25 to 34 years	246	135	54.9	44	17.9
35 to 44 years	416	235	56.5	69	16.6
45 to 54 years	575	263	45.7	151	26.3
55 to 64 years	452	139	30.8	167	36.9
65 years or over	271	29	10.7	92	33.9
Total	2,045	837	40.9	543	26.6

According to this table, at ages under 25, of every 100 deaths from all causes, 42.4 were from consumption, increasing to 56.5 at ages 35 to 44, decreasing subsequently to 30.8 at ages 55 to 64, and to 10.7 at ages 65 or over. The corresponding mortality from respiratory diseases other than consumption was also excessive at every period of life.

There are no similar data for the United States except the industrial insurance mortality statistics of grinders, limited to 128 deaths from all causes, of which 63, or 49.2 per cent, were from consumption. Of the mortality of grinders from respiratory diseases other than consumption, 15 were from pneumonia, 5 from asthma and bronchitis, and 2 from other respiratory diseases. If the deaths from consumption and other respiratory diseases are combined, a total of 85, or 66.4 per cent of the mortality of grinders, was from diseases of the lungs and air passages. The excess in the mortality of grinders from consumption is clearly brought out in the tabular presentation of the proportionate mortality from this disease by divisional periods of life compared with that of all males in the registration area of the United States:[a]

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[a] Report of the Chief Inspector of Factories and Workshops, 1906, pp. 107–109.

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG **GRINDERS**, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for grinders from experience of an industrial insurance company; figures for males in registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of grinders, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Grinders.	Males in registration area, 1900 to 1906.
15 to 24 years	7	4	57.1	27.8
25 to 34 years	24	17	70.8	31.3
35 to 44 years	38	24	63.2	23.6
45 to 54 years	30	12	40.0	15.0
55 to 64 years	20	5	25.0	8.1
65 years or over	9	1	11.1	2.7
Total	128	63	49.2	14.8

While according to this table the proportionate consumption mortality of grinders was excessive at all ages, the excess was most pronounced at ages 25 to 34, when out of every 100 deaths from all causes, 70.8 were from consumption, against a normal expected proportion of 31.3. The data are unfortunately very limited, but they are at present the only trustworthy source of information regarding the mortality of grinders in the United States. The number of deaths is sufficient, however, to warrant the conclusion that the mortality from consumption in this occupation is very considerably above the normal for the general population.

POLISHERS.

The polishing of metal ware is a widely diversified trade, and the term " polisher " is one of general rather than of special significance. Under the term are included metal polishers and buffers working upon steel, brass, gold, and silverware, but no data are available which would permit of a proper classification of polishers according to the metal or material manipulated. The health-injurious effects of this employment have been recognized by all who have written upon the mortality of dusty trades, and the more important facts are summarized by Arlidge in part as follows:

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[a] The registration area, from which mortality statistics were secured by the Bureau of the Census, included in 1906 about one-half (48.8 per cent) of the total estimated population of continental United States.

> After being shaped and ground to the required dimensions, the next business is to burnish or polish the articles. This is accomplished by wheels covered by leather, and also by a thick bundle of linen rags cut and bound together in the form of a wheel, and which, by rapid rotation, assumes the character of a solid mass, and, at the same time, one so soft as to serve better than any other contrivance for the purpose of surface polishing. To assist in giving polish to the articles made various powders are employed; for example, emery, whiting, rouge, powdered pumice, etc. The use of these materials adds vastly to the dust of the trade and to its pernicious results; but no data are in existence to indicate what is its share in the causation of disease as compared with the dust of the grindstones. Still, no question exists that these polishing powders, differing as they do among themselves in physical qualities, differ likewise in the range of their effects upon the lungs.

The rather involved circumstances affecting the polisher's health and mortality are also discussed in The Workers of the Nation, by Mr. Gilson Willets, whose attention appears to have been attracted by the particularly health-injurious conditions of the employment, and whose conclusions are decidedly suggestive:

> Metal polishers who have reached the age of 40 often look like old men. There can hardly be found a trade more deleterious to health, say those who follow it. Among the harmful conditions may be mentioned the liability of the workmen to get their lungs full of flying and impalpable dust, which is composed of metal, minerals, and cotton fiber. They are also, in many cases, deprived of the proper supply of light, and great injury to the eyes thus arises. It is not easy to wear goggles or glasses, as the operator's sight must be of the keenest in order to detect blemishes. There are laws for the protection of this class of workmen, but they are too seldom employed. New York statutes require that at each polishing lathe there shall be an exhaust fan to carry off the dust, that each operative shall have 250 square feet of air to breathe, and plenty of light. It has been claimed that not in 5 per cent of the shops do these desirable provisions prevail. A buffing wheel, making 2,500 revolutions per minute, has wrecked many constitutions. From it, as the polisher applies the metal, a cloud of dust arises, made of particles of cloth and metal, and that is what the operator breathes. Generally the windows are hermetically sealed. Often the walls and floors are covered with the accumulation of years. In the process of brightening silver-plated material there is given forth by the wheel a cloud of dust of which crocus is a large constituent, while from the plating room come fumes of nitric acid. In the process of polishing chandeliers there is much dust set free, which is composed of particles of brass, and permeates the air of the shop. Metal polishers often do not care to complain, because their wages are high. Here is a good field for activity among the factory inspectors, who should force employers to maintain proper conditions in the shops.(a)

(a) The Workers of the Nation, Vol. I, p. 57.

More recent evidence has been presented in the published sickness and mortality experience of the Metal Polishers' Union, regarding which it has been stated that:

> The treasury of this union, in spite of the fact that the men are steady and have no special temptations to excess, was found to be constantly exhausted. The reason is that the death claims eat up all the funds. An investigation of these claims showed that many of the men were dying from pulmonary tuberculosis. There were some deaths from accident, a few suicides, but the rest were all from pulmonary diseases—and pneumonia was very rare as compared with phthisis. The statistics for the last four years show that in 1903, 45 metal polishers died, of whom 43 succumbed to some lung trouble. In 1904 there were but 38 deaths among the metal polishers, of which only 3 were due to other causes than pulmonary disease. In 1905 there were 70 deaths among the metal polishers, 65 of which were due to some form of lung trouble. In New York City a local union having 170 men working exclusively on the precious metals, had 8 death claims in two years, 7 being due directly to tuberculosis, while 400 men employed in all the other branches of the same industry have had but 3 deaths from this cause in the same space of time.

A medical journal, commenting upon the above-quoted facts at the time of their publication, argued very pointedly to the effect that—

> It would seem from these statistics that even the cleanest kinds of dust, without a trace of infectious material in them, may still prove a source of the greatest possible danger and be the indirect cause of tuberculosis. This has been known for some time, but so startling a confirmation of it is sure to emphasize the necessity for taking every precaution for the avoidance of dust. Even what might seem to be the most innocuous of dirt particles may, when inspired, constitute foci of irritation in which tubercle bacilli may readily find a favorable nidus for implantation and growth.

There are, unfortunately, no official vital statistics of polishers except the recorded mortality for Rhode Island for the period 1897 to 1906, which, however, includes only 42 deaths of polishers from all causes, but of this number 14, or 33.3 per cent, were from consumption. There were 4 deaths from pneumonia and 2 from asthma and bronchitis, a total of 20 deaths from diseases of the lungs and air passages, or 47.6 per cent of the mortality from all causes.

The Rhode Island statistics are fully confirmed by the recorded industrial insurance mortality data of polishers, which includes 279 deaths from all causes, of which 108, or 38.7 per cent, were deaths from consumption. Of the mortality of polishers from respiratory diseases other than consumption, 25 were from pneumonia, 5 from asthma and bronchitis, and 5 from other respiratory diseases. If the deaths from consumption and other respiratory diseases are combined, it is found that 51.2 per cent of the mortality of polishers was from diseases of the lungs and air passages. The excess in the mortality of polishers from consumption is clearly brought out in the tabular presentation of the proportionate mortality from this disease by divisional periods of life:

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG **POLISHERS**, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for polishers from experience of an industrial insurance company; figures for males in registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of polishers, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Polishers.	Males in registration area, 1900 to 1906.
15 to 24 years	48	22	45.8	27.8
25 to 34 years	75	42	56.0	31.3
35 to 44 years	68	29	42.6	23.6
45 to 54 years	48	11	22.9	15.0
55 to 64 years	19	4	21.1	8.1
65 years or over	21	....	....	2.7
Total	279	108	38.7	14.8

While according to this table the proportionate consumption mortality of polishers was excessive at all ages under 65, the excess was most pronounced at ages 25 to 34, when out of every 100 deaths from all causes 56 were from consumption, against a normally expected proportion of 31.3. The number of deaths of polishers included in the analysis is sufficient to warrant the conclusion that the mortality from consumption in this occupation is very considerably above the normal for the general population, but below the corresponding averages for grinders.

TOOL AND INSTRUMENT MAKERS.

The manufacture of tools and instruments includes a large number of grinders and polishers, but it is not possible to classify the occupations in detail. In the United States census statistics the industry includes cutlery manufacture, while in English mortality statistics the group comprehends tool, file, and saw makers, cutlers and scissors makers, and needle and pin makers. The statistics of 1900 for the United States return 26,997 males of known ages 15 or over employed in this industry as previously defined, and of this number 666, or 2.5 per cent, were 65 years of age or over. The proportion attaining to old age was, therefore, somewhat larger than expected, considering the high rate of mortality of grinders and polishers, and others employed in the manufacture of tools, instruments, etc. A special investigation into the sanitary conditions of this employment was made by the Massachusetts state board of health in 1907, and the report included a number of very valuable and suggestive references to conditions unfavorable to health and life, from which the following extracts are made:

> From a sanitary point of view, the one important part of this industry is the reduction of the surface of the article in process of manufacture from the roughness of the original casting to the smoothness and brilliancy so necessary and desirable in the finished product. This involves successive treatment by wet grinding, dry grinding on emery and corundum wheels, and polishing with rouge on buffing wheels. Each of these processes, even that of wet grinding on large, coarse, and finer stones, causes to be cast into the air large amounts of fine dust, made up of very fine particles of steel and of the abrasive substance. In establishments properly equipped and conducted, provision is made to reduce the danger of this dust to a minimum by means of hoods connected with a system of exhaust fans or blowers. In spite of the precautions taken to protect their health, a very large proportion of grinders recklessly remove the hoods, and thus expose themselves unnecessarily to this especially dangerous form of dust. They assert that they prefer freedom of movement with dust to the protection afforded by hoods.
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> The workmen are not, as a class, long lived; indeed, the nature of the work is not compatible with longevity, and a person entering upon it in middle life is unlikely to follow it many years. Whatever the age at which the trade is taken up, a man in sound health who has followed it a few years is an acknowledged rarity. A study of the death returns of the city of Northampton, which is one of the centers of this industry, for the past twelve years, yields facts which can be interpreted in only one way. During this period tuberculosis is given as the cause of death in no less than 54.5 per cent of those whose occupation is indicated by "grinder" or "polisher," and in 45.4 per cent of those designated generally as "cutlers," and of the latter 36.4 died of pneumonia. Taken together, the "grinders," "polishers" and "cutlers" returns show that, during this period, diseases of the lungs were responsible for 72.73 per cent of their mortality. As was shown in the preliminary report on this industry, the tuberculosis death rate for cutlers in Northampton is four times as high as that for the entire adult male population.

A serious problem in the cutlery and tool industry is how to secure effective ventilation, and many of the factories and workshops inspected were found to be seriously defective in this respect. A large proportion of the workmen, including many young boys, are exposed to considerable dust, chiefly, of course, in the grinding and polishing departments. While much has been done to improve the sanitary conditions by artificial ventilation, there has been but a very languid cooperation on the part of the operatives themselves, and many, in fact, are interfering with the arrangements made for their protection to the extent of removing the hoods and exhaust pipes installed for the purpose of removing the dust.

The United States census vital statistics do not include the mortality of tool and instrument makers, and the only official statistics are those of the state board of health of Rhode Island. During the decade 1897 to 1906 there were recorded in Rhode Island 44 deaths of tool makers from all causes, and of this number 9, or 20.5 per cent, were from consumption, and 5, or 11.4 per cent, from other respiratory diseases. The total mortality from diseases of the lungs and air passages was 14, or 31.9 per cent, against an expected percentage of 30.3 for all occupied males in Rhode Island. Fortunately there are more conclusive data regarding this occupation. The most valuable official statistics are those for England and Wales, published at decennial intervals in the supplements to the reports of the registrar-general of births, marriages, and deaths. Only two comparatively recent investigations are here referred to. The first of these, for the three years ending with 1892, included 2,529 deaths from all causes, of which 505, or 20 per cent, were from consumption. Of diseases of the respiratory system other than consumption, 384 deaths were from bronchitis, 286 from pneumonia, and 78 from other diseases of this group, a total of 748, or 29.6 per cent, of the mortality from all causes. Combining the mortality from consumption and other respiratory diseases, it is found that 49.5 per cent of the deaths of tool and instrument makers, as previously defined, were from diseases of the lungs and air passages.

The most recent English mortality statistics of tool and cutlery manufacture are for the three years ending with 1902, referred to in the Supplement to the Sixty-fifth Annual Report of the Registrar-General, in part as follows:

> In the occupation as a whole the mortality at ages under 25 is below the standard for occupied and retired males; but among file makers the death rate at these ages exceeds the standard. Beyond age 25 the mortality in the whole occupation, as well as among cutlers and file makers, considerably exceeds the standard. At ages 45 to 65 years the death rate among cutlers is 72 per cent and that of file makers is 84 per cent above the average. Within the main working period of life the comparative mortality figure for the whole occupation is 1,315, or 31 per cent, above the standard. The mortality from lead poisoning is nine times and that from phthisis is nearly double the standard, and these workers suffer excessively from nervous, circulatory, respiratory, and urinary diseases. On the other hand, the mortality from alcoholism and liver disease and from accident is about half the average. Among cutlers and file makers the comparative mortality figures considerably exceed the average for the entire occupation, the figure for the former being 56 per cent above the standard for all occupied and retired males, while that for the latter is 69 per cent in excess. Indeed, these two occupations appear to be the most unhealthy in the whole group of workers in metal. It should be mentioned in this place that the occupation of file maker is one that is specially liable to lead poisoning, the mortality figure for plumbism being no less than 56, whilst among all occupied and retired males the mortality is represented by unity.

File makers experience more than twice the average mortality from nervous diseases and nearly four times the average from Bright's disease, but cutlers experience comparatively little excess of mortality from either of these causes. In both industries the mortality from phthisis is enormous, the figure for cutlers being nearly three times and that for file makers more than twice the standard, and in both occupations the mortality from respiratory diseases approaches double the standard. Both these workers, however, experience a low mortality from influenza, from alcoholism and liver disease, and from accident, while among file makers the mortality from cancer is also less than normal.([a])

The English occupation mortality statistics for men employed at tool, instrument, and cutlery making are quite conclusive of the more or less unfavorable effects of this industry on health. In the table which follows a comparison is made of the mortality from all causes among men in this group with occupied males generally, and the result is decidedly suggestive of conditions in this trade more or less unfavorable to life and health, but in particular at ages 45 or over, when the general mortality of this class exceeds the general average by from 8.24 to 12.26 per 1,000.

MORTALITY FROM ALL CAUSES AMONG **TOOL, INSTRUMENT, AND CUTLERY MAKERS,** COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 for all occupied males.	Death rate for tool, instrument, and cutlery makers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	2.44	2.09	− 0.35	86
20 to 24 years	4.41	3.32	− 1.09	75
25 to 34 years	6.01	6.32	+ .31	105
35 to 44 years	10.22	13.65	+ 3.43	134
45 to 54 years	17.73	25.97	+ 8.24	146
55 to 64 years	31.01	42.05	+11.04	136
65 years or over	88.39	100.65	+12.26	114

The preceding table is self-explanatory and requires no further comment. A more extended comparison is made in the next table, in which the mortality of tool, instrument, and cutlery makers from consumption and other respiratory diseases is compared with the normal mortality of occupied males from these diseases, by divisional periods of life. The comparison shows that at ages 20 or over the mortality from consumption is excessive among tool, instrument, and cutlery makers, but decidedly so at ages 35 to 64, inclusive. The table further shows that the mortality from other respiratory diseases is excessive among men in this class, but decidedly so at ages 45 or over, reaching the highest rate at ages 65 or over, when the excess is 7.69 per 1,000. The two tables, derived from English experience, fully confirm the previous conclusion that the mortality of tool, instrument, and cutlery makers is excessive when comparison is made with the normal mortality of occupied males generally and that this excess is largely because of a high degree of consumption frequency, particularly at ages 25 to 64, when the excess is from 0.91 to 4.09 per 1,000. The table which follows requires no further comment and is otherwise self-explanatory:

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[a] Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales, pp. lxix, lxx.

MORTALITY FROM CONSUMPTION AND FROM OTHER DISEASES OF THE RESPIRATORY SYSTEM AMONG TOOL, INSTRUMENT, AND CUTLERY MAKERS, COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Mortality from consumption.				Mortality from other diseases of the respiratory system.			
	Death rate per 1,000 for all occupied males.	Death rate for tool, instrument, and cutlery makers.			Death rate per 1,000 for all occupied males.	Death rate for tool, instrument, and cutlery makers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	0.54	0.17	−0.37	31	0.24	0.23	−0.01	96
20 to 24 years	1.55	1.57	+ .02	101	.48	.56	+ .08	117
25 to 34 years	2.03	2.94	+ .91	145	.77	1.14	+ .37	148
35 to 44 years	2.74	5.90	+3.16	215	1.66	2.01	+ .35	121
45 to 54 years	3.04	7.13	+4.09	235	3.32	5.40	+2.08	163
55 to 64 years	2.16	5.26	+3.10	244	6.54	10.42	+3.88	159
65 years or over	1.11	1.97	+ .86	177	17.77	25.46	+7.69	143

The recorded industrial insurance mortality statistics of tool and instrument makers include 303 deaths from all causes, of which 101, or 33.3 per cent, were from consumption. Of the mortality of tool and instrument makers from other respiratory diseases, 25 were from pneumonia, 9 from asthma and bronchitis, and 5 from less frequent respiratory diseases. If the deaths from consumption and other respiratory diseases are combined, it is found that 46.3 per cent of the mortality of tool and instrument makers was from diseases of the lungs and air passages. The excess in the consumption mortality of tool and instrument makers is still more clearly brought out in the tabular presentation of the proportionate mortality from this disease by divisional periods of life. While the consumption mortality of tool and instrument makers was excessive at all ages, the excess was most pronounced at 25 to 34, when out of every 100 deaths from all causes 59.3 were from consumption, against a normal expected proportion of 31.3. The analysis of the consumption mortality of tool and instrument makers in detail is set forth in the table below:

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG **TOOL AND INSTRUMENT MAKERS,** 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for tool and instrument makers from experience of an industrial insurance company; figures for males in registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of tool and instrument makers, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Tool and instrument makers.	Males in registration area, 1900 to 1906.
15 to 24 years	40	13	32.5	27.8
25 to 34 years	59	35	59.3	31.3
35 to 44 years	68	24	35.3	23.6
45 to 54 years	56	21	37.5	15.0
55 to 64 years	32	4	12.5	8.1
65 years or over	48	4	8.3	2.7
Total	303	101	33.3	14.8

The preceding observations and statistical data fully confirm the conclusion that tool and instrument makers, including under this term many similar employments, but in particular the manufacture of cutlery inclusive of grinding and polishing, represent a trade subject to decidedly health-injurious circumstances which are responsible for the comparatively high degree of consumption frequency disclosed by both the general vital statistics of the occupation and the observed mortality of this class in industrial insurance experience.

JEWELERS.

The manufacture of jewelry in all its branches involves a large variety of manipulations, including the melting and refining of small quantities of the precious metals, and the handling, shaping, cutting, and polishing of precious stones. An important part of the industry is engraving and die cutting, which, however, for the present purpose, is separately considered as a well-defined occupation, and although often included with jewelers, it is equally often included with printers and compositors. Most of the articles made by jewelers are of small dimensions, such as chains, rings, brooches, pins, and buckles, which require painstaking care in handling and continuous eye-straining attention in shaping and polishing. Aside from the use of gold and silver, many other metals and mineral substances are employed, such as jet, coral, tortoise, bone, ivory, etc. Zinc is also extensively used as an alloy and for coloring purposes. The gems require to be cut with extreme care, and the work of the diamond polisher and lapidary constitutes, next to the gold and silver smith, important separate branches of the trade. The manufacture of artificial gems, made of a paste, chiefly of a vitreous substance prepared from rocks and crystals or flint powder, subsequently treated with nitric acid with lead and borax as a flux, forms another important subdivision of the industry.

The work of the jeweler is naturally an indoor occupation, involving a stooping position, much like that of the engraver. The workshops are generally small and the ventilation is usually poor. The dust generated in the process of hammering, cutting, shaping, grinding, polishing, etc., is considerable, but very minute, and not easily observed. The dust accumulations are preserved and sold to refining plants, for remelting and the recovery of precious substances. The health problem is complicated by the universal use of blow-pipe apparatus and of gas for heating purposes. In large factories the use of machinery is increasing, but chiefly in connection with the manufacture of imitation jewelry and stones.

The unhygienic condition of many jewelry workshops and the general effect of this employment on health were discussed at some length in an early treatise by Thackrah, from which is quoted the following:

> The jewelers' workrooms are generally crowded, and the atmosphere consequently fouled by respiration, animal effluvia, and the smoke of lamps, as well as by the specific exhalations of the manufacture. Its temperature is generally raised, and in summer the heat is excessive. The labor is light, but the confinement to a leaning posture, with the head much depressed, and the elbows generally fixed to the sides of the trunk, for ten, fourteen, or sixteen hours a day, is irksome and injurious. Intemperance is general, and dram drinking especially prevalent. The disorders of which jewelers principally complain are pains and soreness of the chest, disorders of the stomach and liver, and plethoric affections of the head. They enter the employ about 13 or 14 years of age and are obliged to abandon it generally at 45 to 50.([a])

Thackrah continues that " an old jeweler is seldom to be found, and leaving work, they seem to leave the world as well." That this rather unfavorable view regarding the health conditions in the jewelers' trade is not exaggerated is made evident by the fairly trustworthy vital statistics of the trade. The English mortality data of jewelers and allied occupations for the three years ending with 1902, include 2,823 deaths from all causes, of which 598, or 21.2 per cent, were from consumption. In addition to a high mortality from consumption there were 164 deaths from bronchitis and 247 from other respiratory diseases, a total of 1,009 deaths, or 35.7 per cent, from diseases of the lungs and air passages in the mortality from all causes.[a]

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[a] Effects of Arts, Trades, and Professions on Health and Longevity. C. Turner Thackrah, London, 1832, p. 115.

In Rhode Island the jewelry industry has attained to very large proportions, constituting one of the most important industries in that State. During the ten years ending with 1906 the number of deaths of jewelers recorded was 557 from all causes, and of this number 173, or 31.1 per cent, were from consumption, and 51, or 9.2 per cent, from other respiratory diseases; of the total mortality, therefore, 224 deaths, or 40.3 per cent, were from diseases of the lungs and air passages. No corresponding information is available for other States, but in Massachusetts an investigation was made in 1907 into the hygiene of this trade under the direction of the state board of health, the results of which, however, were rather inconclusive. The opinion arrived at regarding the relation of this employment to health was a rather favorable one, it being stated that in general the appearance of the employee "is healthy and many who have followed the industry for twenty or more years speak of the work as being entirely consistent with good health." This favorable opinion, however, may be called into question in view of the very high proportionate mortality from consumption among jewelers and others employed in the jewelers' trade. In amplification of the previous reference to the Rhode Island statistics, it may be stated that during the half century ending with 1902, 1,252 deaths of jewelers were recorded, of which 480, or 38.3 per cent, were from consumption. There were also 80 deaths from pneumonia, 18 from asthma and bronchitis, or a total of 578 deaths, or 46.2 per cent, from diseases of the lungs and air passages in the mortality from all causes.

The recorded mortality of jewelers in industrial insurance experience includes 403 deaths from all causes, of which 113, or 28 per cent, were from consumption. Of the mortality of jewelers from other respiratory diseases, 37 were from pneumonia, 10 from asthma and bronchitis, and 2 from other respiratory diseases. The deaths from consumption and other respiratory diseases combined show that 40.2 per cent of the mortality of jewelers was from diseases of the lungs and air passages. The excess in the consumption mortality of jewelers is still more clearly brought out in the tabular presentation of the proportionate mortality from this disease by divisional periods of life. While the consumption mortality of jewelers was excessive at all ages, the excess was most pronounced at 25 to 34, when out of every

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[a] The English data include watch and clock makers, makers of scientific instruments, and other more or less closely allied trades. For this reason the English statistics are not strictly comparable with other data for jewelers and are, not, therefore, presented here in tabular form.

100 deaths from all causes 59.5 were from consumption, against a normal expected proportion of 31.3. The analysis of the consumption mortality of jewelers in detail is set forth in the following table:

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG JEWELERS, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for jewelers from experience of an industrial insurance company; figures for males in registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of jewelers, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Jewelers.	Males in registration area, 1900 to 1906
15 to 24 years	60	24	40.0	27.8
25 to 34 years	74	44	59.5	31.3
35 to 44 years	50	22	44.0	23.6
45 to 54 years	59	13	22.0	15.0
55 to 64 years	77	7	9.1	8.1
65 years or over	83	3	3.6	2.7
Total	403	113	28.0	14.8

The preceding observations and statistical data confirm the conclusion that jewelers as a class are subject to an excessive mortality from consumption, but in particular at ages 25 to 34, and that this excess is in a large measure the result of health-injurious circumstances connected with the employment.

MANUFACTURE OF GOLD LEAF.

The work of the gold leaf beater is nearly all hand work, excepting in the operation of the rolling machines. The trade is carried on to-day in practically the same manner as in ancient times. The weight of the hammer used will average 18 pounds, which is more than that of the hammer used by the average blacksmith. Girls, as a rule, are employed in connection with the less arduous operations and the final packing of the gold leaves in boxes and packages. The tissue used in connection with this process is coated with red chalk, the dust of which, of course, enters into the atmosphere of the rooms, usually badly ventilated. One of the chief difficulties in connection with ventilation is the fact that the slightest draft of air will carry the scrap of gold leaf from one anvil to another and make packing operations difficult or impossible. Evidence that the fine particles of gold enter the atmosphere is found in the fact that workmen with beards turn in less waste gold than clean-shaven workmen, and they are now required to wash themselves before leaving the shop, the water being filtered for the recovery of the metal contained therein.

Thackrah, writing in 1832, held that gold-beating must be considered a distinct employment, aside from the metal trade generally. Gold-beaters are about half the day engaged in beating the metal with heavy hammers and the rest in spreading the gold leaf on paper. By this change in employment the process affords an excellent alternation of labor and comparative rest. In his opinion, the men were not exposed to health-injurious conditions and were generally healthy and robust.([a]) It is difficult, however, to accept these conclusions in their entirety. The work of the gold-beater is carried on in rooms the air of which is more or less contaminated and where proper provision for ventilation is extremely difficult, if not impossible. The work is commenced at rather early ages and quite a considerable proportion of young persons are employed. Whether gold dust is itself injurious has never been scientifically determined, but it is quite probable that it is less injurious than other metallic dust.

There are no general vital statistics for this occupation other than the published industrial insurance mortality experience data and these are limited to only 25 deaths from all causes. Of this number 7 were from consumption and 5 from pneumonia and other respiratory diseases. For all ages 28 per cent of the deaths were from consumption, and at 25 to 34 the proportionate mortality from this disease was 50 per cent. The very limited number of observed cases does not warrant a final conclusion, but the statistical evidence would seem to confirm the view that the consumption mortality in this occupation is above the average. The sanitary problems in this industry are complicated by the fact that the work is, as a rule, carried on in small shops, to which it is most difficult to apply rational principles of factory legislation.

BRASS WORKERS.

Brass workers, exclusive of brass polishers and buffers, who have been separately considered, constitute a large group of widely diversified and often quite unlike employments. Brass casting, founding, and molding are arduous occupations exposing to the inhalation of considerable quantities of mineral dust more or less mixed with metallic ingredients. Whether brass dust, as such, is more injurious than the dust of iron and steel, for illustration, has not been determined. In the evidence submitted to the Departmental Committee on Compensation for Industrial Diseases by the National Society of Amalgamated Brass Workers,([b]) including about 7,000 members, it was stated that about 2,000 of these were engaged in casting. The trade was said to be divided into pattern making, chasing, casting, finishing, burnishing, polishing, and putting together. The corresponding classification of the trade in the United States follows practically similar lines.[a] Of the groups mentioned, casting and founding were considered the most injurious to health. Burnishing was held to be less injurious than polishing, but the so-called putting together was stated to be decidedly unhealthful on account of the use of white lead. Evidently, in so diversified a trade the degree of dust exposure must vary widely, and at best the degree of injury can only be measured approximately upon the basis of more or less indefinite mortality data. The exposure of brass workers to dust inhalation is only one of a number of specific factors in the trade decidedly injurious to health and life, and of these mention may be made of the exposure to fumes and vapors generated in the smelting processes. Brass founder's ague is a well-defined occupation disease, the symptoms of which are tightness of the chest with indefinite nervous sensation, followed by fever and previous sweating. Zinc and other fumes inhaled are the chief causes of this ailment, and it is quite probable that the lung injury resulting from the inhalation of fine particles of metallic dust is a material contributory cause in brass founder's ague. Arlidge, in summing up the views of other authorities on brass workers' disease, points out that—

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[a] Effects of Arts, Trades, and Professions on Health and Longevity, by C. Turner Thackrah, 1832, p. 48.

[b] Minutes of Evidence, Departmental Committee on Compensation for Industrial Diseases, 1906, p. 75 et seq.

> Besides brass founding, there are other departments in the brass-working business that are damaging to health; and chiefly so by reason of the dust produced. These branches are brass casting, turning, filing, and polishing. The soft nature of brass is opposed to the development of very fine and acuminated particles, and its weight to its rising very freely and to its diffusion in the air. Nevertheless, those turning and filing it show clearly, by their clothes and hair, that it is largely dispersed; the latter getting green, as happens with brass founders. The inhalation of brass dust operates in similar fashion to that seen in connection with other metallic dusts, provoking bronchial catarrh, which advances to bronchitis and ends in fibrosis. It is reported by some writers that phthisis is unusually prevalent, but no reliable statistics are available to support this statement.

More recent investigations in England fully confirm these earlier conclusions. In 1894 a departmental committee was appointed by the secretary of state to report upon the conditions of work as affecting the health of operatives in the manufacture of brass and kindred amalgams. In its report, which was published in 1896, the committee stated as the result of its investigation, first, that brass workers as a class were extensively liable to diseases of the respiratory organs, and, second, that brass founder's ague, so called, was found to result from the inhalation of fumes given off by the molten brass at the time of pouring, but in a less degree it was attributed to the contamination of the workers' food by the fumes, and that this danger was in proportion to the amount of zinc used in the alloy. The subject was also reported upon in much detail in the Report of the Chief Inspector of Factories and Workshops for the year 1905. From this report the following suggestive extracts are made:

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[a] The number of brass workers in the United States in 1900 was 26,760, but of this number 890 were women.

> Altogether some 500 brass workers were examined, and in addition to the filling in by each one of them of the appended form, note was made of the height, weight, chest measurement, and strength of grasp; the heart, lungs, gums, and teeth were, whenever practicable, examined, and the condition as to anemia, paresis, general health, and prevalence of brass founder's ague was determined.
>
> The result of the replies of 216 casters and 199 polishers and others to the question, Do you consider that your health has been in any way injured by working in brass? was that 22.7 per cent of the casters and 11.6 per cent of the polishers and others said they had suffered. This is perhaps the strongest evidence obtained in the inquiry that the casters are exposed to more trying conditions of work than are other brass workers.
>
> The nature of the injury was, as a rule, only very vaguely expressed; in the case of the casters it was nearly always either "fumes" or "sulphur," and in that of the polishers "dust." In one casting shop, where 19 strip casters were examined, of whom 9 said they suffered, illness or discomfort was attributed in some cases to resin fumes in addition to those ordinarily present. Among the casters there were indications that the older the workers were, and also that the earlier the age of commencement of work, the more did they say they had suffered, facts which could not be observed in the case of the polishers.
>
> In 8 casters (3.9 per cent) definite physical signs in the lungs were found, and similarly in 3 (1.5 per cent) of the polishers and others. In two of the casters these pointed to chronic phthisis, while the remainder pointed to bronchial catarrh. I am not inclined to draw any conclusions from these facts, because (1) the number of observations is too small, (2) the examination in some of the factories was carried out under great disadvantages, owing to the impossibility of securing a quiet room, and (3) it is well known that persons who are the subjects of disease of the lungs in any marked degree are not likely to be found at work.
>
> Very strong evidence of the beneficial effect of good exhaust ventilation in connection with all kinds of polishing operations, and indirectly of the lowered state of health from the nonremoval of the dust, was obtained at one factory. Here the opinion of the occupier was that the installation had paid for itself over and over again in the better work which was turned out by the men, and by the improved tone among them resulting from the absence of the obnoxious dust. The remarks of the polishers bore this out. One said, "Worked for eighteen years before the fan was put in, when the dust used to

make him feel sick, but it is not so now." A second said, "I prefer this shop to any other." A third, "I never worked in a cleaner shop;" and a fourth, "The fan is a great improvement."

A large amount of fluff, sand, and lime is given off in the process of polishing with calico mops. It is not, therefore, difficult to understand (even although actual injury to health from it may be hard to prove) that removal of the dust is welcomed as tending to make the work healthier. A sample of dust taken from under a polishing bob was submitted to Doctor Thorpe, who reported: "This sample contains a large proportion of fiber, the loss on ignition amounting to 37.6 per cent. The metallic portion of the residue—copper, zinc, lead, and iron—amounts to 10.56 per cent of the total sample. The lead present equals 0.22 per cent of the total sample, or 2.1 per cent of the above metallic constituents, or, excluding the iron, 2.33 per cent. Microscopically brass dust collected from near an emery wheel showed all the appearances of an injurious metallic dust—fine particles with irregular jagged edges."

Oliver concludes his observations regarding the hygiene of this employment with the following statement:

The necessity of personal cleanliness on the part of workmen and of well-ventilated workshops is apparent. Means ought to be provided for a ready escape of the fumes and for the removal of dust. The workshops ought to be cleaned at least once a year and the walls whitewashed. Hot and cold water should be provided for the men to wash in. The workmen themselves have found out by experience that milk is both a prophylactic or preventive as well as a curative agent. While the use of respirators seems called for, the men can not work well in them. Women and persons under 18 years of age are not allowed to work in the casting shop.

The most recent English mortality statistics of brass workers are for the three years ending with 1902, referred to in the report of the registrar-general in part, as follows:

The mortality of these workers is somewhat below the standard at ages 15 to 20 and 25 to 35 years, but above the standard at every other age group. In the main working period of life their comparative mortality figure is 1,154, or 15 per cent above the average; the greatest excess of mortality occurring under the head of phthisis, the figure for which disease is above the average by 45 per cent. The mortality from diseases of the nervous, circulatory, respiratory, and urinary systems as well as from suicide is also above the average. These workers are only slightly liable to fatal influenza, and their mortality from alcoholism and liver disease is also low. They likewise suffer less than the average from fatal accident. ([a])

The English occupation mortality statistics for brass workers are quite conclusive of the more or less unfavorable effects of this industry on health. In the table which follows a comparison is made of the mortality from all causes of men in this group with occupied males generally, and the result is quite suggestive of conditions in this trade more or less unfavorable to life and health, but in particular at ages 35 to 64, when the general mortality of this class exceeds the general average by from 3.17 to 5.59 per 1,000.

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[a] Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales, p. lxxv.

MORTALITY FROM ALL CAUSES OF **BRASS WORKERS**, COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 for all occupied males.	Death rate for brass workers.		
		Rate per 1,000.	Greater(+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	2.44	2.22	−0.22	91
20 to 24 years	4.41	5.13	+ .72	116
25 to 34 years	6.01	5.86	− .15	98
35 to 44 years	10.22	12.79	+2.57	125
45 to 54 years	17.73	20.90	+3.17	118
55 to 64 years	31.01	36.60	+5.59	118
65 years or over	88.39	83.78	−4.61	95

The preceding table is self-explanatory and requires no further comment. A more extended comparison is made in the next table, in which the mortality of brass workers from consumption and respiratory diseases other than consumption is compared with the normal mortality of occupied males from these diseases, by divisional periods of life. The comparison shows that at ages 20 to 64, inclusive, the mortality of brass workers from consumption is excessive by from 0.42 to 1.79 per 1,000, the excess being greatest at ages 35 to 44. The table further shows that the mortality from respiratory diseases other than consumption is excessive among men in this class, but decidedly so at ages 55 and over, when the excess is from 1.29 to 2.88 per 1,000. The two tables derived from English experience fully confirm the previous conclusion that the mortality of brass workers is excessive when comparison is made with the normal mortality of occupied males generally, and that this excess is largely because of the high degree of consumption frequency, particularly at ages 25 to 54. The table which follows requires no further comment, and is otherwise self-explanatory.

MORTALITY FROM CONSUMPTION AND FROM OTHER DISEASES OF THE RESPIRATORY SYSTEM AMONG **BRASS WORKERS**, COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Mortality from consumption.				Mortality from other diseases of the respiratory system.			
	Death rate per 1,000 for all occupied males.	Death rate for brass workers.			Death rate per 1,000 for all occupied. males.	Death rate for brass workers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	0.54	0.49	−0.05	91	0.24	0.24	....	100
20 to 24 years	1.55	2.17	+ .62	140	.48	.52	+0.04	108
25 to 34 years	2.03	2.93	+ .90	144	.77	.60	− .17	78
35 to 44 years	2.74	4.53	+1.79	165	1.66	2.05	+ .39	123
45 to 54 years	3.04	4.61	+1.57	152	3.32	3.94	+ .62	119
55 to 64 years	2.16	2.58	+ .42	119	6.54	9.42	+2.88	144
65 years or over	1.11	.44	− .67	40	17.77	19.06	+1.29	107

The recorded mortality of brass workers in industrial insurance experience includes 414 deaths from all causes, of which 161, or 38.9 per cent, were from consumption. Of the mortality of brass workers from respiratory diseases, other than consumption, 36 were from pneumonia, 3 from asthma and bronchitis, and 12 from less frequent respiratory diseases. If the deaths from consumption and other respiratory diseases are combined, 51.2 per cent of the mortality of brass workers was from diseases of the lungs and air passages. The excess in the consumption mortality of brass workers is still more clearly brought out in the tabular presentation of the proportionate mortality from this disease by divisional periods of life. While the consumption mortality was excessive at all ages, the excess was most pronounced at ages 15 to 24, when out of every 100 deaths from all causes 59.1 were from consumption, against a normal expected proportion of 27.8. The analysis of the consumption mortality of brass workers in detail is set forth in the following table.

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG BRASS WORKERS, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for brass workers from experience of an industrial insurance company; figures for males in the registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of brass workers, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Brass workers.	Males in registration area, 1900 to 1906.
15 to 24 years	66	39	59.1	27.8
25 to 34 years	112	56	50.0	31.3
35 to 44 years	91	41	45.1	23.6
45 to 54 years	58	14	24.1	15.0
55 to 64 years	54	11	20.4	8.1
65 years or over	33	.....	.....	2.7
Total	414	161	38.9	14.8

The preceding observations and statistical data fully confirm the conclusion that brass workers as a class are subject to decidedly health-injurious circumstances connected with the employment, and resulting in a comparatively high degree of consumption frequency and a death rate from respiratory diseases in excess of the normal at ages 35 or over.

PRINTERS.

The employment of printers differs in many essentials from most of the other occupations considered in this discussion, since it is homogeneous and well-defined and common throughout the country. While in many of the modern printing establishments the conditions favoring health and life, with special reference to ventilation and light, are probably satisfactory, in the smaller workshops the sanitary conditions, as a rule, are decidedly to the contrary, and predispose to tuberculosis. Thackrah early called attention to the diseases of printers, and in his opinion " few appear to enjoy good health." Consumption, according to this writer, was frequent, but apparently caused rather by the confinement or indoor employment than from direct injury to the respiratory organs. The trade is one which has received a considerable amount of attention because of its recognized unhygienic features, and, in addition to the general data upon this subject, the mortality experience of various typographic associations has been carefully investigated. As Oliver points out, " Printing houses should be so constructed that free currents of air can get to them, and not, as is so frequently the case, shut in by other buildings."

But such construction is even to-day the exception rather than the rule. Considering that, as a class, printers probably rank above the average mechanics in intelligence and earnings, it is difficult to understand why they should so persistently in the past have neglected the important problem of workshop hygiene. The successful effort to secure to the members of the craft in illness or old age a home in the mountain region of the West emphasizes what could be done by concentrated effort in other and even more important directions. In the historical sketch of the Union Printers' Home, at Colorado Springs, it is, in fact, pointed out that the place was selected for the location of the home primarily because of the special liability of printers to all forms of lung and throat diseases, and in explanation of the subsequent necessity for a hospital annex the statement is repeated that "consumption is one of the diseases to which the printer is especially liable."

The English vital statistics of printers for 1890 to 1892 are quite conclusive. Out of 2,677 deaths of printers from all causes, 917 were from phthisis, 218 from bronchitis, 186 from pneumonia, and 50 from other diseases of the respiratory system. In every 100 deaths from all causes there occurred, therefore, 51.2 deaths from diseases of the lungs and air passages. In comparing the mortality rates of printers with occupied males generally the health-injurious effects of the occupation, at even very early ages, become very readily apparent. At ages 15 to 19 the rate for occupied males generally was 2.55 against 3.24 for printers; at 20 to 24 the rates were, respectively, 5.07 and 6.61; at 25 to 34, 7.29 and 9.10; at 35 to 44, 12.43 and 14.40; at 45 to 54, 20.66 and 21.56; at 55 to 64, 36.66 and 43.39; and finally, at ages 65 or over, 102.32 and 102.61. This comparison proves conclusively that the excess in the mortality falls very largely upon ages under 35, and at these ages more than half of the mortality from all causes is from diseases of the lungs or air passages, or primarily from consumption.

Tatham, in commenting upon the excessive mortality of printers, as disclosed by an analysis of the English mortality data, remarks that "like bookbinders, printers die very rapidly from phthisis, and probably for a similar reason, namely, because of the excessively unhealthful conditions under which their work is carried on."([a]) Tatham calls attention, however, to the decline in the mortality of printers during the course of the last twenty years, due among other causes to the decrease in the deaths from lead poisoning, which had fallen to one-half of the earlier figure. The frequency of phthisis among English printers had decreased during the decade by one-sixth of the former rate.

In the occupation mortality statistics of the Twelfth Census, printers are grouped with compositors and pressmen, which is to be regretted since there are certain important differences in the disease liability of these allied employments which are sufficiently distinct to warrant separate consideration, at least in the case of pressmen, although the number of the latter is comparatively small. The total number of persons included in this group in the registration States, aged 15 or over, according to the census, was 54,374, but of this number only 818, or 1.5 per cent, had attained to the age of 65 or over.([a]) This rather surprising result is confirmed by the statistics of the New Jersey bureau of labor for 1891, according to which out of 462 printers only 2 had attained to the age of 60 or over. The census mortality statistics of this group of printers, or as stated, compositors, printers, and pressmen, are of some value though not entirely conclusive on account of probable defects in the census enumeration.

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[a] Dangerous Trades, p. 151.

MORTALITY FROM ALL CAUSES AMONG **COMPOSITORS, PRINTERS, AND PRESSMEN**, COMPARED WITH THAT OF THE MANUFACTURING AND MECHANICAL CLASS AND THE MERCANTILE AND TRADING CLASS IN THE REGISTRATION STATES, 1900, BY AGE GROUPS.

[From report of the Bureau of the Census on Vital Statistics, 1900.]

Age at death.	Death rate per 1,000 among—		
	Compositors, printers, and pressmen.	The manufacturing and mechanical class.	The mercantile and trading class.
15 to 24 years	5.05	4.43	2.60
25 to 44 years	12.29	8.35	6.72
45 to 64 years	20.01	20.16	19.91
65 years or over	108.80	105.43	93.79

According to this table the death rate of printers at ages 15 to 24 was 5.05 per 1,000, compared with 4.43 for men in the mechanical and manufacturing class, and only 2.60 for the mercantile and trading class. At ages 25 to 44 the rate was 12.29 for printers, but only 8.35 and 6.72, respectively, for the other two selected groups of occupations. At ages 45 or over the differences in the mortality of printers compared with other occupations were very slight, due in all probability to the fact that on the one hand most of those at all liable to consumption had died, and that on the other many of the impaired in health had left the trade. In addition, there is also the factor of a possible defect in the census enumeration.

Every investigation which has been made into the mortality rate of printers has confirmed these startling facts of health-injurious circumstances apparently inherent in the trade. In Rhode Island, out of 81 deaths of printers recorded during the ten-year period ending with 1906, 21, or 25.9 per cent, were from consumption and 15, or 18.5 per cent, from other respiratory diseases. At the forty-sixth session of the International Typographical Union, held at Milwaukee, Wis., in 1900, a statistical summary was submitted showing that out of 419 deaths of printers, 192, or 45.8 per cent, had been deaths from diseases of the lungs or air passages, including under this term bronchitis, asthma, pulmonary consumption, pneumonia, and all other respiratory diseases. Of the 411 printers whose ages at death were known, 44, or 10.7 per cent, died at the age of 65 or over, while the average age at death was only 41.25 years, compared with 52.2 years for all males aged 15 or over in the registration area of the United States in 1900.

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[a] Report of the Bureau of the Census on Vital Statistics, 1900, p. cclxxxii.

A thorough and extended investigation into the sanitary conditions of the printing trade was published as part of the report of the New York state bureau of labor statistics in 1906, prepared by Mr. George A. Stevens, statistician. This investigation included the entire mortality of the International Typographical Union for the five years ending with 1905, or 2,498 deaths, representing a mean death rate of 12.63 per 1,000. The rate was highest among the printers of New York City, or 16.32 per 1,000, and lowest in Chicago, or 10.12 per 1,000. The average age at death for all printers was not quite 45 years. The disease most frequent and severe among compositors was found to be tuberculosis of the lungs. The average age at death of compositors dying from tuberculosis was only 36.33 years. Out of 2,498 deaths from all causes, 660, or 26.4 per cent, were from tuberculosis, equivalent to an annual mean death rate of 3.34 per 1,000. Pneumonia caused 258 deaths, or 10.3 per cent of the deaths from all causes, equivalent to an annual mean death rate of 1.30 per 1,000. In commenting upon the high degree of consumption frequency the report points out that "scarcely any other occupation furnishes so large a quota of victims from consumption. The domestic life of printers is parallel to that of other artisans in equal financial circumstances. They are fairly compensated for their labor, thus enabling them to have homes as healthful as those procured by the best-paid workmen in any community. Neither can it be said that compositors are ill nourished and therefore rendered more susceptible to the tubercle bacilli. The determining cause of their susceptibility to the harmful process of the great white plague lies in a different direction—neglect of sanitary precautions in composing rooms."([a])

Of the mortality at known ages, from all causes, 18.9 per cent were deaths at 60 years of age or over. Of the 464 deaths in this group, 321 occurred between the ages of 60 and 69, 122 between 70 and 79, 19 between 80 and 89, 1 at age 90, and 1 at age 96.

The statistical data of the mortality rate among printers for the United States are fully confirmed by the corresponding statistics for German printers, which were published in a small treatise on the hygiene of the printing trade by Doctor Lewitt, of Berlin, in 1899. According to this authority, out of 1,390 recorded deaths of printers,

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[a] Report of the New York Bureau of Labor Statistics, 1906, pp. cxxi and cxxii.

798, or nearly 61 per cent, were of diseases of the lungs and air passages, including 630 deaths from consumption. Of the total number, 243 had attained to the age of 60 or over, or 17.5 per cent of the mortality at known ages. The suggestions made by this writer regarding the prevention of tuberculosis and other diseases in the printing trade are eminently practical and feasible in most of the workshops in which printers are employed.

The most recent English mortality statistics of printers are for the three years ending with 1902, referred to in the Supplement to the Sixty-fifth Annual Report of the Registrar-General, in part as follows:

> The death rates of printers were above the standard for occupied and retired males at all ages up to 35 years, but above that age they were below the standard. Within the main working period of life the comparative mortality figure of printers is 994, which practically corresponds to the standard; they show a slightly excessive mortality from influenza, nervous diseases, and Bright's disease; and their mortality from phthisis exceeds the standard by 60 per cent. On the other hand their mortality from circulatory and respiratory diseases is considerably below the average, and they appear to be subject to small risk from fatal accident, and to be but little addicted to alcoholism and suicide.
>
> Since 1880–1882 there has been a continuous decline in mortality from phthisis, liver disease, and accident. It is also worthy of notice that the mortality from lead poisoning is now only one-fifth part as high as it was twenty years ago. From the other causes shown in the table the mortality in this occupation has fluctuated considerably.

The English occupation mortality statistics for printers are quite conclusive of the unfavorable effects of this occupation on health. In the table which follows the mortality from all causes among men in this employment is compared with that of occupied males generally, and the result is decidedly suggestive of conditions in this trade more or less unfavorable to life and health but in particular at the early ages, or 15 to 34, when the excess in mortality is from 1.62 to 0.45 per 1,000. This table is deserving of particular consideration in that it emphasizes the health-destructive circumstances of this employment at a very early period of life. Those who survive to age 35 or over do not apparently experience a decidedly unfavorable mortality in comparison with other occupations, and in this respect the English statistics are confirmed by the United States census statistics previously quoted. While the actual excess in the mortality of printers at ages 20 to 24 is only 1.62 per 1,000, this excess is equivalent to nearly 50 per cent of the normal mortality at this period of life.

MORTALITY FROM ALL CAUSES AMONG **PRINTERS**, COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 for all occupied males.	Death rate for printers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	2.44	3.19	+0.75	131
20 to 24 years	4.41	6.03	+1.62	137
25 to 34 years	6.01	6.46	+ .45	107
35 to 44 years	10.22	10.19	− .03	100
45 to 54 years	17.73	17.76	+ .03	100
55 to 64 years	31.01	30.76	− .75	99
65 years or over	88.39	87.61	− .78	99

The preceding table is self-explanatory and requires no further comment. A more extended comparison is made in the next table, in which the mortality of printers from consumption and other diseases of the respiratory system is compared with the normal mortality of occupied males from these diseases, by divisional periods of life. The comparison shows that at all ages the mortality of printers from consumption is excessive by from 0.49 to 2.11 per 1,000. The excess is most marked at ages 35 to 44, but the difference is a material one at all ages 20 to 64 inclusive. The corresponding mortality from other respiratory diseases among printers was slightly excessive at ages under 20 and comparatively high at ages 65 or over, but below the average at ages 20 to 64, inclusive. Apparently the employment does not predispose seriously to respiratory diseases except such as assume the pulmonary form of true consumption of a rapidly developing type most destructive to young printers at ages under 45. The table which follows requires no further comment and is otherwise self-explanatory.

MORTALITY FROM CONSUMPTION AND FROM OTHER DISEASES OF THE RESPIRATORY SYSTEM AMONG **PRINTERS**, COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Mortality from consumption.				Mortality from other diseases of the respiratory system.			
	Death rate per 1,000 for all occupied males.	Death rate for printers.			Death rate per 1,000 for all occupied males.	Death rate for printers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	0.54	1.03	+0.49	191	0.24	0.36	+0.12	150
20 to 24 years	1.55	3.41	+1.86	220	.48	.37	− .11	77
25 to 34 years	2.03	3.65	+1.62	180	.77	.55	− .22	71
35 to 44 years	2.74	4.85	+2.11	177	1.66	1.24	− .42	75
45 to 54 years	3.04	4.27	+1.23	140	3.32	2.17	−1.15	65
55 to 64 years	2.16	3.42	+1.26	158	6.54	5.16	−1.38	79
65 years or over	1.11	1.60	+ .49	144	17.77	20.76	+2.99	117

The recorded mortality of printers in industrial insurance experience was exceptionally large and representative of the trade, including 1,590 deaths from all causes, of which 613, or 38.6 per cent, were from consumption. Of the mortality of printers from other respiratory diseases, 169 were from pneumonia, 28 from asthma and bronchitis, and 24 from less frequent respiratory diseases. If the deaths from consumption and other respiratory diseases are combined, 52.5 per cent of the mortality of printers was from diseases of the lungs and air passages. The excess in the consumption mortality of printers is decidedly suggestive of a typical indoor employment, where the exposure to the inhalation of metallic dust in minute particles is continuous and more or less unavoidable. While the consumption mortality of printers was excessive at all ages, the excess was most pronounced at 25 to 34, when out of every 100 deaths from all causes 56.3 were from consumption against a normal expected proportion of 31.3. The analysis of the consumption mortality of printers in detail is set forth in the following table:

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG **PRINTERS**, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for printers from experience of an industrial insurance company; figures for males in the registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of printers, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Printers.	Males in registration area, 1900 to 1906.
5 to 24 years	344	167	48.5	27.8
5 to 34 years	439	247	56.3	31.3
5 to 44 years	346	140	40.5	23.6
5 to 54 years	211	42	19.9	15.0
5 to 64 years	142	13	9.2	8.1
5 years or over	108	4	3.7	2.7
Total	1,590	613	38.6	14.8

The preceding observations and statistical data, derived from both American and foreign sources, fully confirm the conclusions that the printing trade is subject to decidedly unfavorable circumstances more or less responsible for the comparatively high degree of consumption frequency disclosed by both the general vital statistics of the occupation and the observed mortality of this class of labor in industrial nsurance experience.

COMPOSITORS.

Compositors, considered as a distinct occupation (for most printers are also compositors), are exposed to practically the same health-njurious conditions as are persons engaged in the other occupations of the printing business, and in addition they suffer from eye strain, which may, under given conditions, affect very seriously the disease-resisting capacity of the system. Stereotyping might have been included here, and its enormous development as a separate branch of the printing trade would warrant special consideration if any really authenticated observations had been made a matter of record useful for the present purpose. In stereotyping the liability to lead poisoning is a serious factor, affecting especially the men employed in melting the alloy and ladling it into the forms. The same observation applies to operatives on linotype machines, but our present information regarding these employments is too indefinite to warrant the conclusion that the exposure to the risk of plumbism increases materially the mortality from tubercular and respiratory diseases. There are no general vital statistics of compositors separate from those of printers and pressmen, since in both American and foreign statistics these employments are considered as a group.

In the occupation mortality statistics of Rhode Island out of 12 deaths from all causes of compositors recorded during the ten years ending with 1906, 3, or 25 per cent, were from consumption and 2 from other respiratory diseases, or a total of 41.7 per cent of the deaths of compositors were from diseases of the lungs and air passages.

There may be included in this brief reference an extract from a letter by Mr. J. W. Sullivan, a New York City printer, in the Typographical Journal for November, 1903, and reprinted in the annual report of the New York bureau of labor statistics for 1906, in part as follows:

> Typesetting is exhaustive work. Standing hour by hour brings on backache, and in some men varicose veins and swollen feet. Sitting on the high printing-office stools doubles the typesetter up, constraining his arm motions and interfering with his digestion. The linotype operator's stool is too low, as it throws his legs into cramped positions. From the pot of molten type metal under his machine comes a trying heat and offensive gases. He must watch the delicate machinery lest it go wrong. The electric light thrown on his copy often sharply conflicts with the daylight. His keyboard work with wrist and fingers and his handling of hot slugs sometimes results in numbness that threatens scrivener's palsy. Whether typesetter or linotype operator, the compositor's brain is active every moment during the workday. Composition can never be wholly mechanical. Attention must be given to deciphering the copy, to spelling, to capitalizing, punctuating, office style, and correcting the lines as composed. Each of these distinct mental acts, on the whole tedious and monotonous, helps to drain the bodily forces. As the brain becomes fatigued its cells shrink. With every type a man sets there is a touch of wear on the cerebral tissue itself, only to be repaired by the restorative operations of nature—through food, rest, and sleep.

The recorded mortality of compositors in industrial insurance experience affords an opportunity to separately consider this employment as distinct from that of printers. The mortality from all causes was 168, of which 59, or 35.1 per cent, were from consumption. Of the mortality of compositors from other respiratory diseases, 19 were from pneumonia, 1 from asthma, and 5 from less frequent respiratory diseases. If the deaths from consumption and from other respiratory diseases are combined, 50 per cent of the mortality of compositors was from diseases of the lungs and air passages. The excess in the consumption mortality of compositors is still more clearly brought out in the tabular presentation of the proportionate mortality from this disease by divisional periods of life. While the consumption mortality was excessive at all ages under 55, the excess was most pronounced at ages 25 to 34, when out of every 100 deaths from all causes 66.7 were from consumption, against a normal expected proportion of 31.3. While at this period of life the proportionate consumption mortality of compositors was higher than the corresponding mortality of all printers, the proportions were somewhat less at other divisional periods of life, and at ages 55 and over the numbers were too small for a safe conclusion. The analysis of the consumption mortality of compositors in detail is set forth in the table below:

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG COMPOSITORS, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for compositors from experience of an industrial insurance company; figures for males in registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of compositors, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Compositors.	Males in registration area, 1900 to 1906.
15 to 24 years	21	6	28.6	27.8
25 to 34 years	54	36	66.7	31.3
35 to 44 years	32	12	37.5	23.6
45 to 54 years	19	3	15.8	15.0
55 to 64 years	33	1	3.0	8.1
65 years or over	9	1	11.1	2.7
Total	168	59	35.1	14.8

The preceding observations and statistical data, derived from industrial insurance experience, confirm the conclusion that compositors as a class are exceptionally liable to diseases of the lungs, and that the degree of consumption frequency is decidedly excessive and apparently more so than in the printing trade as a whole.

PRESSMEN.

Pressmen in printing plants may be separately considered, although the information regarding this occupation is rather fragmentary and inconclusive. Arlidge comments on the hygienic aspects of the employment in part as follows:

> Their old mode of working has been superseded by the wonderful development of the modern printing machine, whereby the pressman has become little else than an attendant upon it; and we see the marvelous machine in newspaper offices strike off, fold, and count the sheets by thousands in an hour. Bodily strength is consequently at a discount, and the disadvantages of the occupation limited to the heat of the press room—caused principally by the heated cylinders of the press, and to a greater or smaller extent, where coal gas and not electricity is used for lighting, by the gas jets. Add to these the noise of the machines, the standing posture, and confinement in the press room and sustained attention to their work, and there remains nothing else calculated to injure the pressman's health, barring circumstances within his own control.

The occupation of pressmen does not appear to have attracted the special attention of American writers on occupation mortality, but it is safe to assume that the disease liability of this class, and in particular the degree of consumption frequency, do not materially differ from the observed mortality of men employed in the printing trade generally. More definite data, however, would supply a much to be desired addition to our at present very limited knowledge regarding the specific occupation mortality of this employment.

ENGRAVERS.

Engravers are not a very numerous, but a widely distributed, class of workmen, whose occupation is sufficiently well defined to warrant separate consideration. According to the census of 1900 there were 11,156 engravers in the United States. Engravers upon copper, steel, or other metals are subject to much the same conditions injuriously affecting health and life, and the differentiation of the employment according to the kind of metal worked upon is not practicable.

The employment decidedly predisposes to consumption, and all the available data indicate an excessive proportion of deaths from this disease among engravers, at least during the active working period of life. Aside from health-injurious factors directly resulting from operations and processes inseparable from the employment, there is also the unfavorable effect of a sedentary occupation demanding a fixed and stooping position. Arlidge has called attention to the fact that there are other accessory conditions unfavorable to health in this employment, such as the frequent use of strong light, severe taxing of the eyes,([a]) and the employment of strong acids.

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[a] For an extended discussion of the cause of eye strain see Biographic Clinics, Vol. IV, by George M. Gould, M. D., Philadelphia, 1906, pp. 61 et seq.; also Popular Science Monthly for December, 1905.

Some fairly conclusive data are available regarding the mortality of engravers, with particular reference to consumption, but as an interesting case of extreme longevity mention may be made of the death of a Mr. Charles Harris at the age of 93, who for more than half a century had been an engraver of the American Bank Note Company. A somewhat similar case was the death of a Mr. James P. Mayer, who, at his death at the age of 83, was considered the oldest American steel engraver on record.

These, however, are but illustrations of exceptions and rather mark the rule of the comparative infrequency of extreme longevity among men in this employment. Thackrah held that "engravers and copperplate printers present few examples of old age," but he may have included printers and lithographers and similar employments under this term. Tracy, writing with reference to more recent and American conditions, holds that engravers, in common with lapidaries and watchmakers, are very liable to phthisis. It is probably quite true, as pointed out by Sommerfeld, that the amount of metallic or mineral dust generated in this occupation is comparatively small in quantity, but it is practically certain to be injurious in its effects just because of the minuteness of the particles. According to Sommerfeld's data, 23.6 per cent of all cases of sickness of engravers were diseases of the lungs and air passages. He suggests, among other points, as a precaution, extreme care in the physical selection of engravers' apprentices to eliminate those already predisposed to consumption. He further suggests the proper ventilation of the workshops, which in most cases is almost entirely neglected. The evidence of such neglect is brought out by the consumption mortality data of this employment for the State of Rhode Island, according to which, out of 142 deaths of engravers recorded during the half century ending with 1902, 45, or 31.7 per cent, were from consumption, against a normal mortality from this disease among men in all occupations in Rhode Island of 17.8 per cent.

The recorded industrial insurance mortality experience of engravers includes 192 deaths from all causes, of which 67, or 34.9 per cent, were deaths from consumption. Of the mortality of engravers from other respiratory diseases, 18 were from pneumonia, 1 from asthma, and 3 from less frequent respiratory diseases. If the deaths from consumption and from other respiratory diseases are combined, 46.4 per cent of the mortality of engravers was from diseases of the lungs and air passages. The excess in the consumption mortality of engravers is still more clearly brought out in the tabular presentation of the proportionate mortality from this disease by divisional periods of life. While the consumption mortality was excessive at all ages, the excess was most pronounced at 25 to 34, when out of every 100 deaths from all causes 61.7 were from consumption, against a normal expected proportion of 31.3. The analysis of the consumption mortality of engravers in detail is set forth in the following table:

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG ENGRAVERS, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for engravers from experience of an industrial insurance company; figures for males in the registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of engravers, 1897 to 1906, due to—		Per cent of deaths due to consumption, among—	
	All causes.	Consumption.	Engravers.	Males in registration area, 1900 to 1906.
15 to 24 years	31	12	38.7	27.8
25 to 34 years	47	29	61.7	31.3
35 to 44 years	42	19	45.2	23.6
45 to 54 years	34	5	14.7	15.0
55 to 64 years	19	2	10.5	8.1
65 years or over	19			2.7
Total	192	67	34.9	14.8

The preceding observations and statistical data, derived from industrial insurance experience, would seem to warrant the conclusion that engravers are subject to more or less unfavorable effects of their employment, resulting in a decidedly high degree of consumption frequency at early ages, but in particular at ages 15 to 44.

SUMMARY OF CONCLUSIONS REGARDING OCCUPATIONS WITH EXPOSURE TO METALLIC DUST.

Ten occupations exposed to metallic dust have been considered in detail. It is not possible in all cases to base conclusions upon identical data, since for a number of occupations no official vital statistics are available. As a method of indicating with approximate accuracy the possible effect of health-injurious employment, use may, however, be made of the statistics exhibiting the age distribution of persons in this group, and when the employments for which the data are available are combined the number of such persons under observation in the last census year was 219,579. Of this number only 3,544, or 1.6 per cent, had attained to an age of 65 years or over, against a normal expected proportion of 4.6 per cent. While it is quite probable that, to a certain extent, this small number of persons of advanced age in occupations exposing to metallic dust is the result of occupation selection, or conditions favorable to the employment of young persons, the result is, nevertheless, decidedly suggestive of conditions more or less unfavorable to health and life. The details of the age distribution are given in the following table, by divisional periods of life, together with the corresponding percentage distribution of all occupied males, the data for both groups being derived from the census of 1900.

NUMBER AND PER CENT OF MALES IN EACH AGE GROUP IN OCCUPATIONS EXPOSED TO METALLIC DUST, COMPARED WITH NUMBER AND PER CENT IN ALL OCCUPATIONS, 1900.

[From report of the Bureau of the Census on Occupations, 1900.]

Age.	Males in occupations exposed to metallic dust.		All occupied males.	
	Number.	Per cent.	Number.	Per cent.
15 to 24 years	75,663	34.4	5,933,720	26.0
25 to 34 years	69,998	31.9	5,993,847	26.3
35 to 44 years	41,246	18.8	4,704,682	20.6
45 to 54 years	19,711	9.0	3,250,259	14.3
55 to 64 years	9,407	4.3	1,856,181	8.1
65 years or over	3,554	1.6	1,063,856	4.7
Total	219,579	100.0	22,802,545	100.0

According to this analysis the proportion of males aged 15 to 34 was unusually large in this group of occupations, or 66.3 per cent, against 52.3 per cent expected. At ages 35 to 44 the proportion was 18.8 per cent for the group under consideration, against 20.6 per cent among occupied males generally, while at ages 45 or over the percentage proportion of males employed in occupations with exposure to metallic dust was only 14.9 per cent, against 27.1 per cent for occupied males generally. Since most of the trades considered do not involve a very considerable amount of muscular labor, it would seem safe to assume that the unfavorable age distribution is the result of a high death rate, rather than because of occupation selection, more or less favorable to the employment of persons below the age of 35 years.

It is unfortunately not possible to present a combined summary of the census vital statistics of males employed in the occupations included in this group, since it is only for printers and compositors that the census data have been made public. If, however, the mortality statistics for printers and compositors are compared with the corresponding statistics for all occupied males, the death rates are above the average and decidedly so at ages 25 to 44. The death rate from consumption was 4.36 per 1,000, against 2.37 for all occupations, while the death rate from other respiratory diseases was slightly below the average, or 1.54 against 1.97 expected.

The occupation mortality statistics of Rhode Island are available for 8 specific occupations with exposure to metallic dust and when combined return 791 deaths from all causes, of which 229 were from consumption and 99 from other respiratory diseases. The corresponding percentages were 29 per cent of deaths from consumption for persons employed in occupations with exposure to metallic dust, against 17.8 per cent for occupied males generally in the State of Rhode Island. The percentage of deaths from other respiratory diseases was 12.5 per cent, which was exactly the same as for all occupied males in Rhode Island.

The English vital statistics for this group of occupations are available for tool and instrument makers, brass workers, and printers and compositors. When the returns for these occupations are combined, they exhibit excessive death rates at every period of life, as set forth in tabular form, as follows:

MORTALITY FROM ALL CAUSES, FROM CONSUMPTION, AND FROM OTHER DISEASES OF THE RESPIRATORY SYSTEM, IN **OCCUPATIONS EXPOSED TO METALLIC DUST**, COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 due to all causes among—		Death rate per 1,000 due to consumption among—		Death rate per 1,000 due to other diseases of the respiratory system.	
	All occupied males.	Occupations exposed to metallic dust.	All occupied males.	Occupations exposed to metallic dust.	All occupied males.	Occupations exposed to metallic dust.
15 to 19 years	2.44	2.73	0.54	0.73	0.24	0.30
20 to 24 years	4.41	5.28	1.55	2.73	.48	.45
25 to 34 years	6.01	6.29	2.03	3.33	.77	.69
35 to 44 years	10.22	11.68	2.74	5.05	1.66	1.62
45 to 54 years	17.73	20.97	3.04	5.22	3.32	3.55
55 to 64 years	31.01	36.03	2.16	3.91	6.54	7.94
65 years or over	88.39	92.52	1.11	1.54	17.77	22.46

The table shows that the mortality from consumption among men in occupations with exposure to metallic dust was decidedly excessive at all ages and extremely high throughout life, while the corresponding mortality rate from respiratory diseases other than consumption was fairly normal and slightly below the average at ages 20 to 44.

The industrial insurance mortality statistics are available for nine occupations included in this group, returning in the aggregate 3,502 deaths from all causes, and of this number 1,292, or 36.9 per cent, were from consumption. The deaths from other respiratory diseases numbered 469, or 13.4 per cent. The expected consumption percentage by the standard adopted for the registration area of the United States was 14.8 per cent for consumption and 11.7 per cent for other respiratory diseases. When the mortality from consumption and from respiratory diseases other than consumption are combined, the proportionate number of deaths among men in occupations with exposure to metallic dust is found to be 50.3 per cent from this group of causes, against 26.5 per cent expected.

PROPORTIONATE MORTALITY FROM CONSUMPTION IN **OCCUPATIONS EXPOSED TO METALLIC DUST**, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for occupations exposed to metallic dust from experience of an industrial insurance company; figures for males in registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths in occupations exposed to metallic dust, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Occupations exposed to metallic dust.	Males in registration area, 1900 to 1906.
15 to 24 years	619	288	46.5	27.8
25 to 34 years	892	510	57.2	31.3
35 to 44 years	739	313	42.4	23.6
45 to 54 years	518	121	23.4	15.0
55 to 64 years	398	47	11.8	8.1
65 years or over	336	13	3.9	2.7
Total	3,502	[a] 1,292	[a] 36.9	[b] 14.8

[a] There were also 469 deaths from other diseases of the respiratory system, or 13.4 per cent of the deaths from all causes.

[b] The per cent of deaths from other diseases of the respiratory system in the registration area was 11.7.

It is evident from the foregoing observations and statistical data relating to a sufficient number of representative employments with exposure to metallic dust, that the health-injurious effects of such exposure are reflected in the comparatively small proportion of persons of advanced years, a high general death rate, and very high specific death rates from consumption and other respiratory diseases.

OCCUPATIONS WITH EXPOSURE TO MINERAL DUST.

In the group of occupations exposing to a continuous and considerable inhalation of mineral dust resulting from industrial processes, have been included for the present purpose the following representative employments: Stone workers, marble workers, glass blowers, glass cutters, diamond cutters, potters, cement workers, plasterers, paper hangers, molders, core makers, and lithographers. These occupations are all more or less subject to an excessive death rate from all causes, but in particular to a decided excess in the proportionate mortality from consumption, and in most cases also to a comparatively high degree of frequency in the occurrence of respiratory diseases. The details of labor conditions as far as they could be conveniently included in the following summary of observations regarding particular trades appear to fully confirm the opinion that the degree of excess in consumption frequency is intimately related and in almost exact proportion to the degree of exposure to continuous and considerable inhalation of mineral dust.

THE STONE INDUSTRY.

The stone industry in the United States is of considerable extent and wide dispersion over practically the entire country. The number of males of known ages 15 or over employed as stone and marble cutters in the United States in 1900, according to the census, was 54,039, but it is quite probable that this total does not include stone polishers, sawyers, and other similar occupations peculiar to the stone industry. The health of stone and marble cutters has, from earliest times, been held to be notoriously bad, and the hygienic importance of this trade was recognized by Ramazzini, who, as far back as 1705, discussed the subject in an entire chapter in his work on occupation mortality, stating that "in hewing marble or stones out of the rock, in polishing and cutting them, they oftentimes suck in, by inspiration, the sharp, rough, and cornered small splinters or particles that fly off; so that they are usually troubled with a cough, and some of them turn asthmatic and consumptive. * * * Our medical histories give many instances of stones found in the stomach and lungs of these workmen, for which we can assign no other material cause but the dusty particles taken in at the mouth and gradually gathered into a heap. * * * Withal, all possible caution must be used to avoid the sucking in of these minute particles at the mouth."

From the earliest to the most recent observers upon the health conditions in this trade, the conclusions have been decidedly unfavorable and suggestive of circumstances more or less possible of material improvement. Oliver, in his treatise on Diseases of Occupation, remarks, with special reference to stone masons:

> The occupation of the stone mason and of the quarryman has for long been regarded as one in which a higher death rate from lung disease occurs than in most occupations. The disease, which usually assumes a chronic character, is slow in its development and progress. As it is attended by the ordinary physical signs and symptoms observed in other forms of pneumokoniosis, the malady calls for no special description other than this, that in contradistinction to miners' phthisis, which occurs in men who work underground, stone masons' phthisis is met with in men who are working in the open air, a circumstance which becomes a strong argument in favor of the dust origin of pneumokonioses as against the bacillary. After a time the lung disease becomes tuberculous, hence the extraordinary fact of the death rate from pulmonary tuberculosis among stone masons and marble cutters, who are following an outdoor occupation, being six times that of bankers and brokers, who are leading an indoor life. This want of harmony between occupation and mortality from pulmonary phthisis is observed in other outdoor occupations than stonecutting. It would appear, therefore, as if the predisposing causes of lung disease are often of greater importance than the exciting—in other words, that the soil is of as much, if not of greater, influence than the seed. The irritation of the lung caused by dust would seem

in some instances, especially in the early stages of the disease, to create a favorable soil for the implantation of the tubercle bacillus, while in the slowly developed forms of pneumokoniosis the hard and unyielding fibrous tissue does not offer the same attractions to the micro-organism, and as a consequence it is in those parts of the lung where the structure is least fibrous that the tubercle bacilli exert their greatest power for harm.([a])

The remarks of Oliver are fully sustained by the available statistical evidence. The secretary of the Operative Masons' Society of London, in his testimony before the committee on industrial diseases, produced the mortality record for Newcastle for the period 1871 to 1896, including an account of 160 deaths of stone masons, and of this number 71, or 44.4 per cent, had died from phthisis, at an average age of only 42.23 years. It was admitted, however, that conditions had improved, and more recent data resulted in a more favorable showing. Out of 253 deaths of stone masons reported in 1905 by the same society, 79, or 31.2 per cent, were deaths from consumption. The same witness stated that the average age at death of those dying from phthisis during 1905 was 44 years, against 51 years for deaths from all causes.([b])

Conditions are probably somewhat different in this country, due to the more general use of pneumatic tools, which generate considerable quantities of fine dust, the complete prevention of which is always difficult and often is impossible. The degree of disease liability varies materially according to the specific occupation, and the risk is less in the case of paving-stone cutters and slate splitters than in the case of monument or custom work, which requires close attention in matters of minute detail and which is more often carried on indoors. Surfacing and carving and cutting with pneumatic tools are the most dangerous employments, and the risk is less in polishing, grinding, sawing, and lathe work, most of which is carried on by the wet process. Large quantities of dust are stirred up, however, in the brushing off and cleaning up of the accumulated dust, and in the moving of materials, dropping of slabs, etc. There is, therefore, more or less dust exposure in all branches of the stone industry, but the results of exposure vary according to the kind of material, which includes a large variety of stones, chiefly, however, granite, marble, limestone, sandstone, bluestone, slate, etc.

The stonecutter's trade is one which requires both skill and arduous physical labor. The men as a rule work in the open air, and in very warm or wet weather under shelter; but all are liable to inhale the dust and small particles from the material upon which they operate. This on some kinds of stone is much more deleterious to health than on others, the stone containing the largest proportion of flints being much more injurious than that which has most lime in it. The returns show that the present age of stonecutters is three years less than that of carpenters or masons, while the average number of years at work exceeds that of either by nearly one year. But this is accounted for by reason of the difference in the ages at which they began to work, which by 63.9 per cent of stonecutters was under 15 years of age; while in the other two trades mentioned it was 13.8 per cent and 4 per cent, respectively. The explanation is that in England, Ireland, and Scotland, as well as in other European countries, seven years are the rule for apprenticeship of stonecutters, and a large proportion are taken when 12 years old, and quite a number under this age. Eighty-three and one-half per cent of the total number were foreign born and but 16.5 per cent American born; and of the latter but nine-tenths of 1 per cent began to work under 15 years of age; while 15.4 per cent of carpenters and 25.6 per cent of masons began to work at their respective trades after the age of 20 years and upward, none of the stonecutters had reached this age. This fully accounts for the differences above noted.([a])

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[a] Diseases of Occupation, London, 1908, p. 305.

[b] Minutes of Evidence, Departmental Committee on Compensation for Industrial Diseases, p. 322.

In his discussion of the hygiene of this occupation Lloyd makes the following observations:

Stonecutters and quarrymen suffer in various degrees from the inhalation of dust. The extent of the evil in their cases depends upon, first, the character of the dust and, second, the circumstances amid which the work is pursued. The quality of the stone has much to do with the extent of pulmonary disease among stonecutters. Some stone is much more dusty than others. A sedimentary stone, for instance, that was formed originally simply by the deposit of earthy and siliceous particles under water is much more liable to give off a large quantity of dust than is a stone that was fused in early geological ages—the igneous stones, for instance, like granite. Although the particles from these latter stones are exceedingly hard, yet there is not much true dust, only the particles actually displaced by the contact with the tool being thrown off. These probably do not carry far in the air, and are mostly too large to gain access to the alveoli as dust. This was the explanation given by Hamilton, of Aberdeen (quoted by Arlidge), for the fact that the masons and polishers at the Aberdeen quarries do not suffer much, if any, with industrial phthisis.

A brief abstract from a special report of the Massachusetts state board of health on dangerous occupations, as suggestive evidence particularly applicable to American conditions at the present time, is also included here:

It is preeminently a dusty trade, and the workmen are, therefore, exposed to the danger of inhaling nonabsorbable and irritating particles of mineral matter. Accidents to the eyes from flying chips are also very common, but they are generally less serious than those due to fragments of steel from the tools employed. Of the various kinds of stone dust, granite is regarded as more injurious than marble, and soapstone the least of all; but different granites vary in this particular, some yielding a much finer dust than others, on account of differences in texture. The greatest amount of dust comes from the surfacing machines, which are operated with compressed air. The tool is either a large hammer or an instrument which presents four smaller separate faces. Sometimes a bushing hammer, made of thin, chisel-like blades bolted together, is used; this creates the finest dust of all. The men who operate the surfacing tools rarely wear masks, but many chew tobacco and spit, in the belief that the practice serves to protect them from the effects of the dust to which they are exposed. Some protect themselves from flying chips by means of wire screens placed about the hammer; some wear wire masks and some wear glasses. By a union regulation, surfacing is done in the open sheds in the yard. While the operation of smoothing can not be done by the wet process, on account of clogging of the tools with the pasty material which would thereby be produced, polishing is conducted with the application of water, which prevents the evolution of dust. The sawing of granite and marble into slabs is conducted ordinarily by the wet process, and is therefore unattended by dust; but soapstone sawing and cutting for joints is frequently done dry, and with the evolution of much fine dust. Turning in lathes is conducted in the wet way, and is dustless.

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[a] Fourteenth Annual Report of the Bureau of Statistics of Labor and Industries of New Jersey, 1891, pp. 176, 177.

Of 343 deaths which occurred in the city of Quincy among stonecutters during a period of about sixteen years, no fewer than 142 (41.4 per cent) were due to pulmonary tuberculosis, 41 (12 per cent) to other diseases of the lungs, 44 (12.8 per cent) to diseases of the heart, 24 (7 per cent) to violence, and 92 (26.8 per cent) to all other causes. Excluding accidents, the percentage due to tuberculosis was 44.5. These statistics show even more strikingly than those quoted in a report submitted two years ago the dangerous character of this occupation. Therein it appears that, of a total of 30,000 deaths among stonecutters, tuberculosis was the cause in 28.57 per cent. It must be said, however, that the average age at death of the victims of the disease in this industry, so far at least as the Quincy records show, is somewhat high (47.8 years), but it is to be borne in mind that the calling is one which is not open to the naturally weak, and that many of those who become incapacitated through infection drift into other lines of industry in which physical strength is not so essential, and hence at death are not returned as belonging to this class.

STONEWORKERS.

No very satisfactory data for this country are available to determine with accuracy the probable degree of difference in the health-injurious conditions resulting from the cutting or manipulation otherwise of the different kinds of stone, such as granite, sandstone, limestone, bluestone, slate, etc., except marble-cutters, to be separately considered as a well-defined branch of the trade. The term stonecutter is, therefore, practically inclusive of all branches of the industry and of all the different employments necessary in connection therewith. An observer of conditions in the sandstone industry states that " stonecutters who work on sandstone seldom live to be 50 years of age, and nearly all of them die of lung disease due to the inhalation of mineral dust;" but how far this is sustained by actual experience in the regions where sandstone is quarried and cut can not be stated at present. A physician of long residence in the New Bedford, Ind., limestone field, states that he has not observed very serious consequences to result from employment in that branch of the stone industry, but all such observations are subject to serious error in the absence of trustworthy statistical data for a period of years.

The Vermont state board of health has reported the mortality by occupations during the six years ending with 1905, and during that time there were 204 deaths from all causes among the granite and stone cutters and workers in that State. Of those deaths 80, or 39.2 per cent, were from consumption, and 27, or 13.2 per cent, from other respiratory diseases. Of the deaths from all causes among granite and stone cutters and workers in Vermont, 52.4 per cent was due either to consumption or to other respiratory diseases.

In the State of Rhode Island during the period 1897–1906, 125 deaths of stone and marble cutters and workers were recorded, and of this number 40, or 32 per cent, were from consumption, compared with the average of 17.7 per cent for men in all occupations in that State. The census mortality statistics for 1900 combine marble and stone cutters into one group, including 26,141 males aged 15 years or over in the registration States. Of the number stated, 659, or 2.5 per cent, had attained to 65 years of age or over, which compares with 3.9 per cent for men in mechanical and manufacturing industries generally. In the mortality from all causes the death rate was comparatively low at ages under 25, but high at ages 25 or over, as shown in detail in the table following. The census mortality statistics, however, are subject to the criticism that in all probability the facts are understated on account of defective enumeration, and the table must, therefore, be used with caution.

MORTALITY FROM ALL CAUSES AMONG MARBLE AND STONE CUTTERS, COMPARED WITH THAT OF THE MANUFACTURING AND MECHANICAL CLASS AND THE MERCANTILE AND TRADING CLASS, IN THE REGISTRATION STATES, 1900, BY AGE GROUPS.

[From report of the Bureau of the Census on Vital Statistics, 1900.]

Age at death.	Death rate per 1,000 among—		
	Marble and stone cutters.	The manufacturing and mechanical class.	The mercantile and trading class.
15 to 24 years	3.35	4.43	2.60
25 to 44 years	9.32	8.35	6.72
45 to 64 years	24.72	20.16	19.91
65 years or over	122.91	105.43	93.79

A further difficulty in connection with the vital statistics of stone and marble cutters results from the fact that men in this trade are a very mobile element, frequently moving from one place to another in response to better trade conditions, higher wages, etc., in other fields. The most suggestive results of the census mortality investigation is the extraordinary death rate from consumption, which is returned at 5.41 per 1,000, compared with 2.62 for the mechanical and manufacturing class, and 1.66 for the mercantile and trading class. The statistics of Rhode Island and the United States census of 1900 confirm, therefore, the conclusion that consumption among men employed in the stone industry is of exceptional frequency and in fact by far the most common cause of death.

For reasons unknown, the Report of the Registrar-General for England and Wales does not specifically consider stonecutters, but they are combined with quarrymen in stone and slate, which, of course, precludes the utility of the resulting averages in an effort to determine the relative degree of consumption frequency in a well-defined specific occupation such as the stonecutter's trade. Even when considered as a group, however, quarrymen and stonecutters combined, according to English statistics, show an excessive mortality from consumption and other respiratory diseases, but it is a matter of regret that the data should not be separately available for men employed in the more important branches of the stone industry.

The recorded industrial insurance mortality experience of stoneworkers includes 858 deaths from all causes, of which 302, or 35.2 per cent, were from consumption. Of the mortality of stoneworkers from respiratory diseases other than consumption, 95 were from pneumonia, 13 from asthma, 30 from bronchitis, and 24 from less frequent respiratory diseases. If the deaths from consumption and from respiratory diseases other than consumption are combined, it is found that 54.1 per cent of the mortality of stoneworkers was from diseases of the lungs and air passages. The excessive mortality from lung diseases among stoneworkers is therefore sustained by all of the numerous investigations which have been made into the health conditions of this employment. The excess in the consumption mortality of stoneworkers is still more clearly brought out in the tabular presentation of the proportionate mortality from this disease by divisional periods of life. While the consumption mortality was excessive at all ages, the excess was most pronounced at ages 35 to 44, when out of every 100 deaths from all causes 47.7 were from consumption against an expected normal proportion of 23.6. The analysis of the consumption mortality of stoneworkers in detail is set forth in the table following.

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG STONEWORKERS, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for stoneworkers from experience of an industrial insurance company; figures for males in the registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of stoneworkers, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Stoneworkers.	Males in registration area, 1900 to 1906.
15 to 24 years	21	10	47.6	27.8
25 to 34 years	114	60	52.6	31.3
35 to 44 years	172	82	47.7	23.6
45 to 54 years	232	91	39.2	15.0
55 to 64 years	199	52	26.1	8.1
65 years or over	120	7	5.8	2.7
Total	858	302	35.2	14.8

The preceding observations and statistical data, including the industrial insurance mortality experience of this class, fully confirm the conclusion that this occupation is to be classed as decidedly unhealthful and that the degree of consumption frequency is materially above the normal at all ages, but that the excess is most marked at ages 35 to 44.

MARBLE WORKERS.

Marble workers constitute a distinctive and well-defined group of the stone industry, which it has seemed best to consider separately, though most of the general statistics appertaining to the occupation are included in the stone industry considered as a whole. The American marble industry is centered chiefly in Vermont, where about 60 per cent of all the marble produced in the United States is quarried, and most of it is cut and dressed, sawed, or polished, as the case may be, in the locality where quarried. The Vermont state board of health has for some six years past reported the mortality by occupations, and of the deaths of marble workers reported in that State, out of a mortality of 42 from all causes, 5 were from consumption and 5 from other respiratory diseases. The fact that Vermont is an otherwise exceptionally healthful State goes far to mitigate the intrinsic dangers of the occupation resulting from continuous exposure to the inhalation of stone dust.

Bertillon, in his observations on morbidity and mortality, refers to stonecutters and workers in marble in Switzerland as being subject to a considerable mortality, principally from phthisis, which rapidly increases with age. Under 20 years of age, according to this authority, it is rarer than among the mass of the population; from 20 to 29 it equals the average, from 30 to 39 it is double, from 40 to 49 it is triple, and from 50 to 59 it is four times the average rate of the Swiss as a nation. He also refers to Italian statistics, which are significant on account of the remarkable development of the marble industry at Carrara, stating that stonecutters and pavers average fewer days of sickness than the whole population up to 45 years, but considerably more above that age. At Paris the workers in marble are subject to a high death rate at all ages.

A very instructive descriptive account of the machine process as generally employed in the marble industry was included in the report on the stone industry for 1908, by Mr. W. C. Day, of the United States Geological Survey, from which the following extract is made as emphasizing the more or less health-injurious circumstances of employment in marble manufacture:

> After being sawed the slabs are placed on a "rubbing bed," which consists of a circular cast-iron plate, from 8 to 15 feet in diameter, the older forms having a circular opening from 1 foot to 18 inches in diameter in the center. The plate is planed to a smooth surface and is mounted upon running gear so that it may revolve in a horizontal plane. Fixed arms, usually four in number, are sustained radially about one-fourth of an inch above the plate, either by an upright passing through the central opening or by a framework overhead (in the case of the newer solid forms of bed). The slabs of stone to be polished are placed upon the bed in front of the arms, and the bed is revolved slowly beneath them in such a direction as to hold them firmly against the arms. An abrading material, such as sand, sometimes mixed with "chilled shot," or crushed steel, with a constant supply of water, is fed upon the plate. If necessary, the stones are weighted to increase the friction. From this rubbing bed the slabs are removed to the emery bed, which is similar to the former, fine emery being used for abrasion. They are then rubbed down by hand with a fine, evenly grained sandstone, commonly called a "Scotch hone," with a sufficient supply of water, and smoothed off with pumice stone and water. The final polish is put on by rubbing the slabs upon a buffing bed, similar in form to the rubbing bed, but covered with a thick, specially prepared felt, upon which a small amount of "putty powder" (oxide of tin) is fed, to give a high gloss. The hand process consists in grinding on the rubbing bed as before, and then rubbing down by hand successively with Nova Scotia "blue stone," "red stone," "Scotch hone," and pumice stone, after which it is glossed with putty powder, or, in case of cheaper "onyxes" and common marbles, with a mixture of two parts of oxalic acid and one part of tin oxide.

In marble cutting, as in the stone industry generally, the introduction of pneumatic tools operated by compressed air has brought in a new and decidedly health-injurious factor, since the amount of dust generated by this process is very much greater than when the work is done entirely by hand with the ordinary chisel and mallet. Portable stone-dressing machines have been invented and quite widely adopted, since in part the quality of the work done by these machines is superior to hand work, while the productive capacity is claimed to be from eight to fifteen times as much as when the work is done entirely by hand. Exhaust air is employed to keep the stone clean at the point of impact of the cutting tool, but the clouds of dust raised by this apparatus are considerable, even though the work is usually done outside of the shed. Aside from the dust generated in either machine or hand cutting, a vast amount of dust is produced during cleaning-up operations, and while labor organizations have, in part, provided against this risk by special regulations, the generation of much dust is practically unavoidable under the existing methods by which the work is carried on.

The United States census mortality statistics combine marble and stone cutters, so that it is impossible to separately consider statistically the mortality of this employment. As has been previously pointed out in discussing stonecutters generally, the evidence is entirely conclusive that the mortality from consumption and other respiratory diseases among this class is decidedly excessive. It is observed in the report on Vital Statistics of the census of 1890 (Vol. I, p. 144) that "it will be seen from the preceding table that among marble and stone cutters in the United States the greatest proportion of deaths was due to consumption, being much greater than the average proportion due to this cause in this class. The proportion of deaths of marble and stone cutters in the United States due to diseases of the respiratory system was greater than the average proportion in this class." The respective rates per 1,000 living were 3.15 for consumption against an average of 2.11 and 1.91 for other respiratory diseases against an average of 1.54 among occupied males in manufacturing and mechanical industries generally.

The recorded industrial insurance mortality statistics of marble cutters include 200 deaths from all causes, of which 56, or 28 per cent, were from consumption. Of the mortality of marble workers from respiratory diseases other than consumption, 26 were from pneumonia, 7 from asthma and bronchitis, and 3 from less frequent respiratory diseases. If the deaths from consumption and from respiratory diseases other than consumption are combined, 46 per cent of the mortality of marble workers was from diseases of the lungs and air passages. The excess in the consumption mortality of marble workers is less than the excess in the consumption mortality of stoneworkers generally, and this fact is still more clearly brought out in the tabular presentation of the proportionate mortality from this disease by divisional periods of life. While the consumption mortality was high during the entire active working lifetime of marble workers, the excess in the mortality was most pronounced at 25 to

34, when out of every 100 deaths from all causes 50 were from consumption, against a normal expected proportion of 31.3. The analysis of the consumption mortality of marble-cutters in detail is set forth in the table below:

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG MARBLE CUTTERS, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for marble-cutters from experience of an industrial insurance company; figures for males in registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of marble cutters, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Marble-cutters.	Males in registration area, 1900 to 1906.
15 to 24 years	3	....	....	27.8
25 to 34 years	30	15	50.0	31.3
35 to 44 years	40	16	40.0	23.6
45 to 54 years	46	16	34.8	15.0
55 to 64 years	50	7	14.0	8.1
65 years or over	31	2	6.5	2.7
Total	200	56	28.0	14.8

The preceding observations and statistical data, derived from industrial insurance mortality experience, confirm the conclusion that the degree of dust exposure in this occupation is about the same as among stoneworkers generally and that the degree of consumption frequency among marble cutters is materially above the average, but decidedly so at ages 25 to 34.

THE GLASS INDUSTRY.

The glass industry in the United States gives employment to some 50,000 wage-earners, of whom about 10 per cent are children under 16 years of age. The industry is a varied one, including among others the manufacture of blown and pressed ware, of window glass and plate glass, and finally of so-called crystal or cut glass, which for the present purpose is considered as a separate industry. The labor division of the trade includes numerous and well-defined occupations, each of which is subject to more or less injurious circumstances, but of these the handling of materials and the mixing are the most liable to the risk of continuous inhalation of mineral dust. The most important employment is that of the glass blower, but there are few accurate statistics which separate this employment from the industry as a whole. For the present purpose, however, it has seemed best, as far as practicable, to consider the mortality of glass blowers by itself, although the medical observations subsequently to be quoted refer more or less to glass workers as a class. Changes in manufacturing processes and the introduction of labor-saving machinery have resulted in sanitary improvements, which in consequence have had a favorable effect upon the health of glass blowers, at least in the United States, as far as the rather fragmentary statistical data can be relied upon. Among glass workers as a class, consumption is of exceptional frequency, in addition to which there is a comparatively high mortality from other respiratory diseases, lead poisoning, and heat prostration.

Thackrah, writing in 1832, held that glass workers as a class were liable to catarrh and cough, but not to pleurisy and pneumonia. He commented upon the appearance of a fine dust at the furnaces which, however, in his opinion did not produce any marked effect on the health of the operatives. He also mentioned individual cases of glass workers remaining at their employment at ages 70 to 80, but in the majority of instances failing eyesight at ages 50 to 60 disqualified for the employment. Thackrah's account of this occupation was, however, very superficial, and some of his conclusions were not at all in conformity to the facts as reported by other authorities. Tracy, writing in 1879, held that—

> In the manufacture of glass the workmen who grind and powder the siliceous material inhale great quantities of very irritating dust, and suffer from constant hacking cough and conjunctivitis. It is rare to find a sound man among them, and they are not able to continue long at the work. According to Hirt, they should not be allowed to labor, at a stretch, more than two or three weeks, and should then work at something else, or, at any rate, give up this occupation for at least double the working time. In this way, by the use of relays, the health of the men may be sustained.([a])

Since the health-injurious effects of any given industry are, to a certain extent, measured by the proportion of those who attain to advanced ages, it is of interest to note that out of 47,245 glass workers in the United States of known ages, only 392, or 0.8 per cent, had attained to age 65 or over. The age distribution of male glass workers in the United States, according to the census of 1900, was as follows:

NUMBER AND PER CENT OF MALE GLASS WORKERS IN EACH AGE GROUP, COMPARED WITH NUMBER AND PER CENT OF MALES IN ALL OCCUPATIONS, 1900.

[From report of the Bureau of the Census on Occupations, 1900.]

Age.	Male glass workers.		All occupied males.	
	Number.	Per cent.	Number.	Per cent.
10 to 14 years	2,849	6.0	875,342	3.7
15 to 24 years	17,882	37.9	5,933,720	25.1
25 to 34 years	13,314	28.2	5,993,847	25.3
35 to 44 years	7,625	16.1	4,704,682	19.9
45 to 54 years	3,838	8.1	3,250,259	13.7
55 to 64 years	1,345	2.9	1,856,181	7.8
65 years or over	392	.8	1,063,856	4.5
Total	47,245	100.0	23,677,887	100.0

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[a] Buck's Hygiene and Public Health, Vol. II, pp. 36, 37.

The actual numbers, as well as percentages, of glass workers at advanced ages is surprisingly small. It is evident that the rapid diminution of the number at work after age 35 must be partly, at least, the result of a high death rate at the younger ages, and in particular an excessive mortality from consumption, which at this period of life causes from one-third to one-half of the deaths from all causes. Tatham, in Oliver's Dangerous Trades, considers this employment at some length, and his observations, based largely upon English mortality data, are quoted in part as follows:

> The making, blowing, and engraving of glass occupies a prominent place among unhealthy trades for several reasons. In the first place, the workers are exposed to extreme variations of temperature—in some processes, that of glass blowing especially, the operatives are constantly exposed to the intense heat of the furnace, as well as to that which radiates from the pots of molten glass which they are engaged in blowing. The intense heat and profuse sweating naturally induce painful thirst, which the workmen evidently allay by excessive drinking; this is shown by the fact that their mortality from alcoholism and from nervous disorders is nearly double that experienced by operatives in other trades. * * * The comparative mortality figure for glass makers is 1,487, and is, therefore, in excess of the average by 56 per cent. Phthisis and diseases of the respiratory system are especially fatal to workmen in this industry, and they suffer more severely than other occupied males from diseases of the circulatory, digestive, and urinary systems, as well as from cancer. Since 1881 the mortality of glass workers has increased considerably, and this is true of the younger as well as the older workers in this industry.

The English mortality statistics upon which these conclusions rest include 1,092 deaths of glass workers, and of this number 229, or 21 per cent, died from consumption. At ages 25 to 34, however, out of 177 deaths of glass workers from all causes, 79, or 44.6 per cent, were from consumption. Of the mortality from other causes, bronchitis caused 146 deaths, pneumonia 123, and other respiratory diseases 25. These combined with deaths due to consumption make a total of 523, or 47.9 per cent, from diseases of the lungs and air passages in the mortality of glass workers from all causes. The most recent English mortality statistics of glass manufacture are for the three years ending with 1902, referred to in the Supplement to the Sixty-fifth Annual Report of the Registrar-General, in part as follows:

> In this occupation the death rates exceed the standard for occupied and retired males at all stages of life by proportions ranging from 12 to 32 per cent. In the main working period the comparative mortality figure is 1,260, or 25 per cent above the standard. The excess of mortality among these workers is most marked in the case of plumbism, phthisis, respiratory diseases, and Bright's disease; they

also suffer heavily from influenza and from diseases of the nervous and circulatory systems. The mortality from alcoholism, accident, and suicide, however, is below the average.

The recent English mortality statistics for glass workers are quite conclusive of the more or less unfavorable effect of this industry on health. In the table which follows the mortality from all causes among men in this group is compared with that of occupied males generally, and the result is decidedly suggestive of conditions in this trade more or less unfavorable to life and health. The excess in the general death rate of glass workers is met with at all ages, but the relative and actual excesses are greatest with advancing years, being 6.41 per 1,000 at ages 45 to 54, 10.83 at 55 to 64, and 30.99 at 65 or over.

MORTALITY FROM ALL CAUSES AMONG **GLASS WORKERS**, COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 for all occupied males.	Death rate for glass workers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	2.44	3.22	+ 0.78	132
20 to 24 years	4.41	5.09	+ .68	115
25 to 34 years	6.01	6.74	+ .73	112
35 to 44 years	10.22	13.14	+ 2.92	129
45 to 54 years	17.73	24.14	+ 6.41	136
55 to 64 years	31.01	41.84	+10.83	135
65 years or over	88.39	119.38	+30.99	135

The preceding table is self-explanatory and requires no further comment. A more extended comparison is made in the next table, in which the mortality of glass workers from consumption and other respiratory diseases is compared with the normal mortality of occupied males from these diseases, by divisional periods of life. The comparison shows that the mortality from consumption is excessive at all ages, 15 to 64 inclusive, the excess being most marked at ages 35 to 54. The table further shows that the mortality of glass workers from other respiratory diseases is excessive at all ages, the excess being most marked at ages 45 or over. The two tables derived from English experience fully confirm the previous conclusion that the mortality of glass workers is excessive when comparison is made with the mortality of occupied males generally, and that this excess is largely because of the high degree of consumption frequency at ages 25 to 54, and a high mortality from other respiratory diseases at ages 35 or over. The table which follows requires no further comment and is otherwise self-explanatory.

MORTALITY FROM CONSUMPTION AND FROM OTHER DISEASES OF THE RESPIRATORY SYSTEM AMONG **GLASS WORKERS**, COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Mortality from consumption.				Mortality from other diseases of the respiratory system.			
	Death rate per 1,000 for all occupied males.	Death rate for glass workers.			Death rate per 1,000 for all occupied males.	Death rate for glass workers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years.....	0.54	0.56	+0.02	104	0.24	0.28	+ 0.04	117
20 to 24 years. ...	1.55	1.81	+ .26	117	.48	.60	+ .12	125
25 to 34 years.....	2.03	2.88	+ .85	142	.77	.99	+ .22	129
35 to 44 years.....	2.74	4.56	+1.82	166	1.66	2.43	+ .77	146
45 to 54 years.....	3.04	4.87	+1.83	160	3.32	5.76	+ 2.44	173
55 to 64 years.....	2.16	2.97	+ .81	138	6.54	10.75	+ 4.21	164
65 years or over...	1.11	....	....	....	17.77	28.68	+10.91	161

GLASS BLOWERS.

The recorded industrial insurance mortality statistics of glass blowers include 282 deaths from all causes, of which 85, or 30.1 per cent, were from consumption. Of the mortality of glass blowers from respiratory diseases other than consumption, 17 were from pneumonia, 3 from asthma and bronchitis, and 6 from less frequent respiratory diseases. If the deaths from consumption and from other respiratory diseases are combined, 39.4 per cent of the mortality of glass blowers was from diseases of the lungs and air passages. The excess in the consumption mortality of glass blowers is still more clearly brought out in the tabular presentation of the proportionate mortality from this disease by divisional periods of life. The consumption mortality was excessive at all ages under 55, but the numbers at ages 55 or over are too small for a safe generalization. The excess in the mortality was most pronounced at ages 25 to 34, when out of every 100 deaths from all causes 56.4 were from consumption, against a normal expected proportion of 31.3. The analysis of the consumption mortality of glass blowers in detail is set forth in the table following.

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG GLASS BLOWERS, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for glass blowers from experience of an industrial insurance company; figures for males in registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of glass blowers, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Glass blowers.	Males in registration area, 1900 to 1906.
15 to 24 years	24	11	45.8	27.8
25 to 34 years	78	44	56.4	31.3
35 to 44 years	59	15	25.4	23.6
45 to 54 years	55	11	20.0	15.0
55 to 64 years	26	1	3.8	8.1
65 years or over	40	3	7.5	2.7
Total	282	85	30.1	14.8

The preceding observations and statistical data confirm the conclusion that glass blowers as a class are subject to an excessive mortality from consumption, but in particular at ages 15 to 44, and this excess, in view of the conditions of labor briefly described, is in a large measure the result of health-injurious circumstances connected with the employment.

GLASS CUTTERS.

Glass cutters, including under this term all who are employed in the manufacture of crystal or so-called cut glass, constitute a separate and well-defined occupation division in glass manufacture. The most important employments are roughing, smoothing, polishing, and puttying, but of these the last named is the most injurious, chiefly because of a specific liability to lead poisoning. The sanitary aspects of the employment have received the special consideration of a British committee on dangerous trades, which, in its Third Interim Report, remarked, with special reference to the injurious effects of putty powder in the form of dust, that—

> It will thus be seen that all persons employed in places where "putty powder" is used, though themselves not handling it, are liable, through inhalation of the dust, to illness and even death through juxtaposition with those engaged in its use. Under existing circumstances the wet powder splashes onto the clothes not only of the polisher who uses it, but onto those of his neighbors; it gets dry after a time, comes off in fine dust, and enters the system either by inhalation through the lungs or by swallowing or through the pores of the skin.

Among other recommendations for the amelioration of the more or less health-injurious conditions inherent in this employment, the committee suggested that all persons engaged in the department of glass cutting and powdering, where putty powder, so called, is used, should be examined once a month by the certifying surgeon for the district, who should be empowered to order temporary or permanent suspension of work.

Aside from the exposure to the inhalation of dust containing lead or other metallic ingredients, there is a further liability to the inhalation of considerable quantities of mineral dust in a large variety of forms. It would obviously be very difficult to estimate with even approximate accuracy the degree of lung injury resulting from dust exposure in glass cutting and polishing, but it is the opinion of qualified authorities that practically every branch of the trade is more or less affected, with a resulting excess in the mortality from consumption. Tracy comments briefly upon the health-injurious aspects of this occupation in part as follows:

> But the most dangerous work is that of the grinders and polishers of cut glass. About 35 per cent of them have chronic pneumonia (phthisis), and their average age at death is variously given at from 30 to 42 years. Putégnat (de Lunéville) has described a peculiar form of gingivitis which he has observed among glass cutters, and which, he says, attacks 95 out of every 100 workmen. It comes on in about three months after the person begins work, and toward the sixth month is well developed. It attacks by preference the upper jaw, and is accompanied by the same blue line that is found in cases of lead poisoning. The acid secretion of the gums destroys the enamel of the teeth, which soon become pointed, brittle, and break off close to the alveoli, leaving a permanent stump. The gums remain soft and spongy, and the breath is very fetid. At no time is there any pain or hemorrhage. He supposes it to be caused by malnutrition, bad air, etc. (Tardieu). These symptoms certainly appear suspiciously like those of lead poisoning, and the suspicion is rendered stronger by the fact that French flint glass contains about 20 per cent of lead, and that other symptoms of lead poisoning are not uncommon in glass cutters, as colic, constipation, muscular pains, etc. Garrod has noticed the frequency of gout among them, and brings it forward to support his theory of a connection between that disease and saturnine poisoning.
>
> The grinding or etching of glass by the sand blast fills the rooms with a dust composed of particles of sand and glass mingled. The business is a comparatively new one, and the workmen so far do not appear to be injured by it, with the exception of a slight tickling cough when they first begin work. The dust is rather coarse and heavy, and I am inclined to think it does not penetrate very far into the lungs, perhaps not even getting beyond the trachea, whence it is easily expectorated.

Lloyd also considered this employment, holding that—

> Flint glass contains lead, being chemically a compound of silicon (silicic acid) with an alkaline and an earthy base, the latter being represented by lead. It is this flint, or lead, glass that is used for cut glass because of its brilliancy. The glass cutter's mill is a revolving disk of wrought or cast iron on which is fed a mixture of sand and water, with which the cutting and polishing are accomplished. In this process, which requires the artisan to bend closely over his mill, dust and fine particles of glass are given off. Emery and putty powder also are used, the latter containing lead. These are the noxious agents by which these cutters and polishers of flint glass acquire lead poisoning.

There are, unfortunately, no official vital statistics of this occupation, since the comparatively small group of cutters of crystal glass is included in the census vital statistics with glass workers generally. Cutters of crystal glass are continuously and considerably exposed to the inhalation of fine particles of mineral dust, which must indeed disastrously affect the lungs of the workmen, but in particular such as are otherwise predisposed to consumption. The suggestion of Oliver and others that crystal glass polishers and cutters should be periodically medically examined for cases of lead poisoning applies equally to the purpose of discovering incipient cases of tuberculosis more or less the result of the employment. ([a])

The recorded industrial insurance mortality statistics of glass cutters include 116 deaths from all causes, of which 40, or 34.5 per cent, were from consumption. Of the mortality of glass cutters from respiratory diseases, other than consumption, 12 were from pneumonia, 1 from asthma, and 2 from less frequent respiratory diseases. The numbers are rather small for a safe generalization, but if the deaths from consumption and from respiratory diseases other than consumption are combined 47.4 per cent of the mortality of glass cutters was from diseases of the lungs and air passages. The excess in the consumption mortality of glass cutters is more clearly brought out in the tabular presentation of the proportionate mortality from this disease by divisional periods of life. While the consumption mortality was excessive at all ages under 55, the numbers being too small for definite conclusions for older ages, the excess was most pronounced at ages 25 to 34, when out of every 100 deaths from all causes 46.7 were from consumption, against a normal expected proportion of 31.3.

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[a] For additional references to the health-injurious circumstances in glass cutting and polishing, see the Reports of the Chief Inspector of Factories and Workshops for 1895, Vol. I, p. 36; 1896, p. 25; 1899, pp. 16, 313; 1900, p. 207; 1901, Part I, p. 220. For a descriptive account of the various manufacturing processes, see Scientific American for April 30, 1904.

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG GLASS CUTTERS, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for glass cutters from experience of an industrial insurance company; figures for males in registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of glass cutters, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Glass cutters.	Males in registration area, 1900 to 1906.
15 to 24 years	26	7	26.9	27.8
25 to 34 years	30	14	46.7	31.3
35 to 44 years	27	11	40.7	23.6
45 to 54 years	20	5	25.0	15.0
55 to 64 years	8	1	12.5	8.1
65 years or over	5	2	40.0	2.7
Total	116	40	34.5	14.8

The preceding observations and statistical data confirm the conclusion that glass cutters as a class are subject to an excessive mortality from consumption, but in particular at ages 15 to 44, and this excess, in view of the conditions of labor briefly described, is in a large measure the result of health-injurious circumstances connected with the employment.

DIAMOND CUTTERS.

Diamond cutting, although an employment of rather limited extent in the United States, is of interest and importance as an occupation with exposure to mineral dust. Hand cutting is very rare and machine cutting is at the present time the general rule in the trade, as carried on under American conditions. There has been a decided improvement as the result of the active efforts of the Diamond Polishers' Union, which has a membership of about 400 in New York City alone. The occupation has the advantage of being well paid, at least in many individual instances, and some of the cutters are reported to receive as much as $80 and polishers as much as $60 a week.

The process of diamond cutting and polishing consists of two parts. After the stone has been cut it is taken to the polishing room, where the setter selects a suitable sized brass cup, called a dope, fills it with a mixture of lead and tin and melts it in a gas flame. After working the solder to its proper shape, he places the diamond in the center, leaving only a very small part exposed. A mark is made on the solder before it becomes fairly set, and then the stone is passed on to the polisher. By the mark made on the solder the latter knows at once the exact run of the grain and the way it will polish to the best advantage. The polisher uses a circular disk composed of very porous iron, so that as the diamond is polished away in the form of dust it enters the pores of the iron, the result being that diamond cuts diamond.

According to Hirt, the first-mentioned process is exceedingly unhealthful. The bent position of the workman, the heat, and the danger of lead poisoning all contribute to make the occupation an unhealthful one. The principal bad features of the second process are the dust inhalation and the straining of the eyes. While very little dust escapes into the air, the little, according to Hirt, is very bad in its effects, as the particles are angular, sharp, and, of course, very hard.

Arlidge in his observations upon the diamond cutter's trade remarks, however, that—

> From our own observation of diamond cutting and polishing we can scarcely imagine any definite morbid result from the dust of the gem. It is far too precious to fritter away into dust by any coarse grinding likely to give off a tangible quantity of this substance, and we suspect that the recorded ill health of diamond workers is chiefly attributable to accidental circumstances connected with the charcoal furnaces formerly used; to overheated and badly ventilated workshops, and to dissipated habits among the employees. So far as diamond dust may possibly be thrown off in the polishing process, so far, doubtless, would it be an irritant to the respiratory organs by reason of the very sharp and angular character of its atoms.

The employment is divided into cutters, splitters, and polishers. In Amsterdam, the chief center of the industry, some 9,000 persons are employed, according to a report by United States Consul Hill. The hygienic conditions of the trade in Amsterdam, however, are apparently less satisfactory than in the United States. The principal factors detrimental to health result from the use of tin and lead as an alloy, and a prize has been offered by the Dutch Government for a nonpoisonous composition, but thus far the requirements governing the award of the prize appear not to have been complied with. Tracy comments upon the sanitary aspects of the employment as follows:

> In diamond cutting the amount of dust created is small, and yet the occupation is a very injurious one. The "setter" prepares the diamond for the cutter by soldering it on the end of a copper rod with an alloy of 4 parts lead to 1 of tin. He does this with a charcoal fire, and is exposed to great heat, as well as to poisonous gases. The setters suffer from headache, tinnitus aurium, impaired digestion, and irregularity of the bowels. In Coster's factory, at Amsterdam, 73½ per cent of them were pale and emaciated, 57 per cent had palpitation, giddiness, præcordial distress, 56 chronic headache, 36 asthma, etc. The use of solder produces lead poisoning. Out of 90 examined, 30 showed traces of poisoning. In general, they are all sick men, and suffer from lung troubles. Nine per cent had phthisis. The cutters or polishers grind the gems on iron wheels covered with

diamond dust and oil. The dust inhaled by them, though small in quantity, is enough to cause frequent chronic lung troubles. In Coster's factory, 52 per cent of them were thin and pale, 40 per cent asthmatic, 33.75 suffered from headaches, etc.

No American vital statistics of this occupation have been published, but the occupation is evidently one which requires to be classified among unhealthy trades and in which the degree of consumption frequency is the result, more or less, of the continuous and considerable inhalation of mineral dust.

POTTERS.

The pottery industry includes the manufacture of earthenware, china, and porcelain. It always has been recognized as one of the unhealthiest of trades, but the health-injurious effects vary widely according to particular employments. The most seriously exposed are the dippers, flint-mill workers, ground layers, mixers, scourers, and sweepers. In all of these employments except the first the exposure to health-injurious mineral dust constitutes a serious menace to health. In the case of dippers the liability to dust inhalation is modified and increased in seriousness by the risk of lead poisoning. The degree of dust exposure is also very serious in the case of kilnmen, mold makers, placers, pug-mill workers, sagger makers, and slip makers. In the aggregate the industry gives employment in the United States to about 16,000 persons, of whom one-fifth are women. The sanitary conditions of the trade have often been investigated, and the most recent evidence is to the effect that there have been material improvements within the last few decades. The most careful and useful observations of the industry were made by Arlidge, who for many years lived in the Staffordshire pottery district of England. Before quoting Arlidge the fact may be briefly referred to that as early as 1705 Ramazzini, in commenting upon the diseases of potters, pointed out that "not all who go by the name of potters are subject to the particular diseases of the trade," and that discrimination was necessary in the medical treatment of the different classes of employees. Ramazzini made a curious observation bearing upon the question of eye strain, which has only received qualified consideration within recent years, stating, with reference to potters, that "those who sit at the wheel and form the vessels by turning it about with their feet are apt to have a swimming in the head if their eyes are otherwise weak."

Arlidge, in discussing the effects of mineral dust in the manufacture of pottery before the Sanitary Institute in 1893, remarked at the outset that—

> Scarcely any other manufacture has so strong a claim upon the attention of sanitarians as has that of pottery. It stands nearly at the

head of the list of unhealthy occupations, and exercises its pernicious effects almost wholly upon the respiratory organs, by production of bronchitis and of consumption. Thus it is found that while workmen engaged in other employments have a mortality from chest diseases of 7.86 per cent, potters exhibit one of 12.29 per cent. Likewise with respect to phthisis—nonpotters present one of 9.27 and potters one of 12.90.

After describing the various processes of manufacture and their relation to health-injurious circumstances, Arlidge discussed the relation of silica dust and its irritating effects upon the mucous membrane and epithelium of the lungs, holding the opinion that—

> Clinical observation abundantly confirms this fact. For a considerable time the inhaled dust is arrested in its advance toward the lung tissue proper by the mucous secretion in the bronchial tubes, and by the expulsive energy of the cilia lining of those tubes. But at length these resistant forces weaken before the constant entry of fresh dust, and in course of time the noxious material passes into the lymph channels, and also along the finer bronchi, until it reaches the intimate structure and the air cells themselves. Here as a foreign substance it sets up inflammatory action; lymph cells spring up, the air vesicles become choked with inflammatory products, the tissue around them gets indurated (lung sclerosis), and useless as breathing tissue.
>
> The history of these pathological changes is reflected in the symptoms exhibited by the sufferers. In the primary stage little inconvenience is felt; there arises a desire to clear the throat of some impeding mucus at the end of the day's work, or upon transition to the outer air from the warm shop, and especially on rising in the morning. This expulsive act soon develops into a cough, and relief is obtained by the expectoration of more or less blackish viscid mucus. Presently there is a feeling of tightness in the chest, and the breathing grows less free and full. As time goes on these signs of disturbed lung function become more pronounced, and in the end the patient grows asthmatic—a victim of potter's asthma.
>
> Until this advanced stage of disorder is reached, it is singular to notice how little attention and anxiety are bestowed upon the pulmonary derangements. This is because the general health is, for the most part, not seriously affected, and inasmuch as while the sufferer breathes a warm air in his workshop or home, his lung trouble is felt as little more than an annoyance; or as something which is to be taken as a matter of course, and like his wages, as an unavoidable incident of his calling.
>
> As with chronic maladies at large, so with potter's bronchitis and asthma; the tendency is to grow worse and the lung lesion to extend, and soon the damaged respiration reacts upon the whole frame; the sufferer can not get proper outdoor exercise, his appetite fails, his sleep is broken, the expectoration augments and grows muco-purulent, the body wastes slowly, while the increased effort to breathe entails strain upon the heart, leading not infrequently to disease of that organ, with the after consequences in the shape of dropsical effusions.
>
> We now have before us the fully developed disease known as potter's consumption or potter's asthma.

The injurious effects of silica dust in the pottery industry are materially increased by minute particles of flint, and a further factor injurious to health is the extensive use of plaster of Paris, employed in the making of molds and models. According to Arlidge, the effects of plaster of Paris dust, however, are not apparently as serious as the very destructive effects of silica dust and small particles of flint. He draws attention to the necessity of an efficient system of ventilation as the only means by which material improvements can be brought about.

The health-injurious effects of lead, extensively used in potteries, which do not properly fall within the present discussion, must here be passed over. It is true, of course, that a considerable amount of lead dust is inhaled, but the effects are rather upon the system generally than upon the lungs. The observations of Arlidge are so entirely sustained by other qualified observers that it is not necessary to further enlarge upon the sanitary aspects of this trade. The evidence, statistical or otherwise, is conclusive that potters as a class suffer more, perhaps, from phthisis and other diseases of the lungs than employees in any other occupation, and their mortality from bronchitis and other respiratory diseases is many times as high as the mortality of occupied males generally, but it has been pointed out by Tatham, in his contribution to Oliver's Dangerous Trades, that—

> Potters succumb to nontubercular disease of the lungs much more rapidly than they do to tubercular phthisis; and it is certain that much of the so-called potter's phthisis ought properly to be termed cirrhosis of the lung. Deaths from this affection should never be included under the head of phthisis, which term is now restricted, by universal consent, to the tubercular malady of that name.

It is also necessary to keep in mind, in discussing the pottery industry, that it divides itself broadly into two principal departments—that is, first, the making of the articles from potter's clay, and, second, their ornamentation by painting, gilding, etc. The latter group is usually defined as decorators, and sometimes as printers, and because of this fact many errors occur in occupation statistics as the result of erroneous classification—not based upon the industry as such, but upon the specific title of the employment.

One of the most health-injurious employments in the industry is that of the brushing, or dusting off, of the ware after it is taken from the kilns. Oliver, in discussing at length the sanitary aspects of china and earthenware manufacture and in particular potter's asthma and consumption, draws special attention to this process as observed in the porcelain potteries at Limoges. He states that—

> The brushing off or époussetage of the fired or biscuited ware is done both by women and men by means of soft feather brushes. It

is a very dusty operation, and where there are no fans for its removal, as in some of the factories I visited, the air was thick with dust. The windows were open at the time, but currents of air obtained by this means exercised no very appreciable influence upon the dust. It is not this kind of ventilation that is required under these circumstances. In the matter of the provision of artificial means for the removal of dust and the renewal of air in the potteries of Limoges, some of the manufacturers seemed to me to be rather behind than in advance of the owners of large factories in Staffordshire. Accordingly I was not unprepared for the information that among the potters, especially the brushers off or scourers, in Limoges, the mortality from pulmonary consumption and chest diseases is high. The harmful operations in porcelain works are the emptying of the kilns, the removal of the ware from the saggers and the brushing of this ware, while the hard dust that rises during the polishing of the all but finished articles is equally dangerous. The polishing has for its object the removal of any roughness from the edges or surfaces of the ware, and it is generally done on a revolving wheel by means of a broken piece of china, the workman using this as a smoothing agent. The men and women employed in these operations are usually well covered with dust, yet it is seldom that they wear respirators. Fans for the removal of the dust were present in only very few of the factories. The employees objected to them on the ground that they created a strong draft of cold air. Doctor Raymondaud, one of the professors in the School of Medicine, Limoges, has made a special study of the diseases of porcelain makers, particularly of pulmonary consumption and chronic bronchitis. He found that the potteries furnished a larger number of patients suffering from lung diseases than did the other trades of the district. Of 75 deaths registered in Limoges as occurring among china makers, 36 were due to phthisis, and of 30 potters whom Raymondaud examined, 20 were suffering from pulmonary consumption. Pulmonary phthisis is regarded as the principal disease affecting the workers in the Limoges potteries.

The most recent English mortality statistics of potters are for the three years ending with 1902, referred to in the Supplement to the Sixty-fifth Annual Report of the Registrar-General, in part as follows:

Between the ages 20 and 35 years the mortality of potters falls below that of occupied and retired males generally; at every other age, however, it shows an excess which amounts to no less than 74 per cent at ages 45 to 55 years, and to 66 per cent at ages 55 to 65 years. In the main working time of life the comparative mortality figure is 1,493, or 49 per cent above the standard. The principal excess falls under the head of respiratory diseases, for which the mortality figure is 473, or nearly thrice the standard. There is also a considerable excess in the mortality from phthisis, from nervous and circulatory diseases, and from suicide. These workers are also specially liable to lead poisoning, but from accident as well as from influenza, Bright's disease, and alcoholism their mortality is low.

In the last decennial supplement the mortality of potters was described as enormous. From the present report, however, it will be seen that since 1890–1892 their mortality has declined at every stage of life; and in the main working period the comparative mortality figure has fallen from 1,970 to 1,420, or by no less than 28 per cent. It is satisfactory to note that in the recent period the mortality of potters from plumbism has fallen to less than half its former amount, while there has also been a substantial decline under most other headings; the mortality from respiratory and urinary diseases having fallen by about one-third, that from phthisis, nervous and digestive diseases by about one-fourth, and that from circulatory diseases by about one-fifth part. Potters, however, now fall victims in increased proportion to accident, and to suicide, and the mortality from cancer has increased by more than half. Since 1860, 61, 71 the death rates of potters both above and below 45 years of age have fluctuated somewhat, but the recent modified mortality figure is by far the lowest on record. Since 1880–1882 there has been a continuous decline of mortality from phthisis, from liver disease, and from diseases of the nervous and digestive systems.

The English statistics for potters are quite conclusive of the unfavorable effects of this industry on health. In the table which follows the mortality from all causes among potters is compared with that of occupied males generally, and the result is decidedly suggestive of conditions more or less unfavorable to life and health, but in particular at ages 35 or over, when the mortality rate from all causes exceeds by from 4.30 to 29.86 per 1,000 the corresponding mortality of occupied males generally.

MORTALITY FROM ALL CAUSES AMONG **POTTERS**, COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 for all occupied males.	Death rate among potters.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	2.44	2.62	+ 0.18	107
20 to 24 years	4.41	3.68	− .73	83
25 to 34 years	6.01	5.26	− .75	88
35 to 44 years	10.22	14.52	+ 4.30	142
45 to 54 years	17.73	31.64	+13.91	178
55 to 64 years	31.01	54.15	+23.14	175
65 years or over	88.39	118.25	+29.86	134

The preceding table is self-explanatory and requires no further comment. A more extended comparison, however, is made in the next table, in which the mortality of potters from consumption and from other diseases of the respiratory system is compared with the normal mortality of occupied males from these diseases, by divisional periods of life. The comparison shows that the mortality from consumption among potters is decidedly excessive at ages 35 to 64 by 1.05 to 4.10 per 1,000. Still more marked is the excess in the mortality from respiratory diseases other than consumption among potters at ages 35 or over, which varies from 1.63 to 17.27 per 1,000. The table which follows requires no further comment and is otherwise self-explanatory:

MORTALITY FROM CONSUMPTION AND FROM OTHER DISEASES OF THE RESPIRATORY SYSTEM AMONG **POTTERS**, COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Mortality from consumption.				Mortality from other diseases of the respiratory system.			
	Death rate per 1,000 for all occupied males.	Death rate for potters.			Death rate per 1,000 for all occupied males.	Death rate for potters.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	0.54	0.62	+0.08	115	0.24	0.46	+ 0.22	192
20 to 24 years	1.55	1.34	− .21	86	.48	.58	+ .10	121
25 to 34 years	2.03	2.00	− .03	99	.77	.64	− .13	83
35 to 44 years	2.74	3.79	+1.05	138	1.66	3.29	+ 1.63	198
45 to 54 years	3.04	7.14	+4.10	235	3.32	10.78	+ 7.46	325
55 to 64 years	2.16	4.37	+2.21	202	6.54	23.10	+16.56	353
65 years or over	1.11	.97	− .14	87	17.77	35.04	+17.27	197

With further reference, however, to the excessive mortality from respiratory diseases among potters, which, as subsequently to be shown, is confirmed by industrial insurance mortality experience, reference may be made to the discussion of the occurrence of potters' asthma, in the Report of the Departmental Committee on Industrial Diseases. The evidence submitted to the committee disclosed a decided improvement in the disease liability of potters to the fibroid form of phthisis, based upon the records of the North Staffordshire Infirmary, at Stoke-upon-Trent, covering the period 1873–1906. Upon a basis of 10,000 patients, the number of cases of fibrosis of the lungs was found to have been 145 during the six years ending with 1878, 107 during the six years ending with 1897, and only 4 during the six years ending with 1906.([a]) In the opinion of a qualified medical witness, the diminution was not the result of a difference in the practice of diagnosing, but a real reduction in the prevalence of the disease. The improvement in the disease liability was attributed to a betterment in the conditions of work and a more effective method of factory supervision, inspection, and control. Aside from these favorable conclusions, however, the general mortality statistics of this trade indicate continued unfavorable circumstances, reflected in the decidedly excessive degree of consumption frequency and a correspondingly excessive mortality from other respiratory diseases in the more advanced years of life.

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[a] Minutes of Evidence, Departmental Committee on Compensation for Industrial Diseases, p. 60.

The recorded industrial insurance mortality statistics of potters include 384 deaths from all causes, of which 127 or 33.1 per cent were deaths from consumption. Of the mortality of potters from respiratory diseases other than consumption, 21 were deaths from pneumonia, 18 from asthma, 12 from bronchitis, and 6 from less frequent respiratory diseases. If the deaths from consumption and from other respiratory diseases are combined, 47.9 per cent of the mortality of potters was found to be from diseases of the lungs and air passages. The excess in the consumption mortality of potters is still more clearly brought out in the tabular presentation of the proportionate mortality from this disease by divisional periods of life. While the consumption mortality was excessive at all ages, the excess was most pronounced at ages 25 to 34, when out of every 100 deaths from all causes, 52.9 were from consumption, against an expected normal proportion of 31.3. The analysis in detail of the consumption mortality of potters is set forth in the table below:

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG **POTTERS**, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for potters from experience of an industrial insurance company; figures for males in registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of potters, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Potters.	Males in registration area, 1900 to 1906.
15 to 24 years	46	11	23.9	27.8
25 to 34 years	68	36	52.9	31.3
35 to 44 years	84	37	44.0	23.6
45 to 54 years	78	22	28.2	15.0
55 to 64 years	72	14	19.4	8.1
65 years or over	36	7	19.4	2.7
Total	384	127	33.1	14.8

Since potters are liable to an excessive mortality not only from consumption, but also from respiratory diseases generally, the analysis of the industrial insurance mortality experience has been extended to respiratory diseases other than consumption, and the number of deaths from such diseases, by divisional periods of life.

PROPORTIONATE MORTALITY FROM DISEASES OF THE RESPIRATORY SYSTEM OTHER THAN CONSUMPTION AMONG **POTTERS**, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for potters from experience of an industrial insurance company; figures for males in registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of potters, 1897 to 1906, due to—		Per cent of deaths due to respiratory diseases other than consumption among—	
	All causes.	Respiratory diseases other than consumption.	Potters.	Males in registration area, 1900 to 1906.
15 to 24 years	46	1	2.2	9.7
25 to 34 years	68	8	11.8	10.9
35 to 44 years	84	10	11.9	12.5
45 to 54 years	78	18	23.1	12.6
55 to 64 years	72	17	23.6	12.2
65 years or over	36	1	2.8	11.6
Total	384	[a] 57	14.8	11.8

[a] Including 2, age unknown.

While respiratory diseases have been grouped for purpose of convenience, and on account of the comparatively small number of deaths under consideration, the returns in detail disclose the fact that it is particularly in the number of deaths from asthma that potters experience a higher mortality than occupied males generally.

In summarizing these rather extended observations and statistical data, including insurance mortality experience, the conclusion is confirmed that potters as a class are decidedly subject to a high mortality from consumption and from respiratory diseases other than consumption.

CEMENT WORKERS.

The health-injurious conditions of cement-making processes are quite well understood, being on the one hand the dust, and on the other hand noxious vapors arising through the process of burning. The vapors are probably more obnoxious than injurious, but the subject attracted sufficient attention to suggest an investigation by the Royal Commission on Noxious Vapors, in 1878. As a result of the vapors and the dust generated during the processes, cement works, as a rule, are located outside of large cities.

The health conditions in cement works have never been fully investigated, but it appears to be the consensus of opinion that the effects are not as serious as assumed upon the facts of a casual inspection. Fatal accidents have occurred as the result of asphyxiation by carbon-monoxide gas, but such cases are very rare. Cases of gassing, so-called, which do not terminate fatally, are comparatively common. Arlidge considered the employment of cement making at some length, pointing out that the workmen are exposed to dust in an intense form, but the experience would seem to prove that the effect on health is not as serious as expected. He states that the raw materials of cement are clay with flint and lime, and he briefly describes the process of manufacture as follows:

> After the materials have been well mixed and ground together in a sort of mortar mill to the consistency of liquid mud, the next business is to drive off the water by heat, and then to subject the dried substance in tins to a still higher temperature. Later all the cement is withdrawn and then ground between rollers to the requisite fineness. The primary mixing and grinding, being done with a free supply of water, exhibits no unsanitary conditions. In working the kilns the workmen suffer from great heat and dust, but the most continuous dusty work is in the mill, the air of which is clouded with cement. Inquiry among the workmen elicited the fact that after a while they become short of breath and suffer cough, though not in a high degree, and that on arising in the morning they had to clear their chests by expectorating viscid mucus containing cement dust.

The amount of dust generated in cement-making processes is enormous. The workmen take practically no precaution to avoid this dust, and considerable quantities are of necessity inhaled. It is very rare to find employees who use a respirator or even a piece of ordinary cloth to provide some protection against the health-injurious conditions which surround them. The conditions are probably at their worst in the sacking or packing department, where such precautions are occasionally adopted. Every department, however, is filled with dust, and the avoidance of its inhalation by the majority of employees is under present methods practically impossible. The disease problem is complicated by a high degree of temperature in some of the departments, in particular at the kilns. While many descriptive accounts of the industry have been published, the hygiene of the occupation has been practically ignored. Tracy refers to it very briefly, holding that " the workmen who make Portland cement are greatly troubled by the dust, caused by shoveling the mass into sacks after it has been burned and ground. They have a persistent cough, and expectorate little lumps of cement. They find it impossible to continue this part of their labor day after day, and are obliged to take intervals of rest."

Parry, in his treatise on The Risks and Dangers of Various Occupations, refers to cement workers as follows:

> Those engaged in the manufacture and use of Portland cement are very liable to get the dust into their lungs. Portland cement is made from some substance containing carbonate of lime, such as white chalk, existing in such immense quantities in this country, and some material containing silica and alumina, such as a selected clay,

or alluvial mud. These are ground together with water to a muddy consistency, which is then dried by heating in chambers. This being a wet process no dust is raised, but during the next stage, the digging out of the cement, a great deal of dust is created. The material raised is then calcined, ground between rollers, and finally packed in bags. In the last two operations, the grinding and packing, much dust is also scattered. The particles are of a sharp, irritating character, and therefore dangerous.

In Oliver's Dangerous Trades, the manufacture of cement from a hygienic point of view is briefly discussed and illustrated by a microphotograph of cement dust by Migerka. Oliver's description is as follows:

> Under the microscope are seen a few sharp-edged little plates and amorphous masses like small clumps. The particles are not of themselves so dangerous as might at first sight appear. Although cement workers suffer from pulmonary disease, they do not do so to the great extent that might be expected. Probably the harmful effects are largely due to the hygroscopic character of the particles and their alkaline reaction.

There are no official vital statistics of this employment for the United States or for England and Wales. The recorded industrial insurance mortality statistics of cement workers include only 88 deaths from all causes, of which 17, or 19.3 per cent, were deaths from consumption. Of the mortality of cement workers from other respiratory diseases, 5 were from pneumonia and 3 from other diseases of that class. If the deaths from consumption and from other respiratory diseases are combined, it is found that 28.4 per cent of the mortality of cement workers was from diseases of the lungs and air passages. The excess in the consumption mortality of cement workers is more clearly brought out in the tabular presentation of the proportionate mortality from this disease by divisional periods of life:

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG **CEMENT WORKERS,** 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for cement workers from experience of an industrial insurance company; figures for males in the registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of cement workers, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Cement workers.	Males in registration area, 1900 to 1906.
15 to 24 years	10	1	10.0	27.8
25 to 34 years	12	3	25.0	31.3
35 to 44 years	19	4	21.1	23.6
45 to 54 years	15	6	40.0	15.0
55 to 64 years	19	3	15.8	8.1
65 years or over	13			2.7
Total	88	17	19.3	14.8

The foregoing observations confirm the conclusion that cement makers as a class are subject to conditions more or less injurious to health, but the evidence is as yet inconclusive that these conditions predispose to an excessive mortality from consumption.[a]

PLASTERERS.

The building trades are all more or less exposed to the inhalation of mineral dust, the injurious effects of which are probably most severe in the case of plasterers, masons, and allied occupations. This group of occupations is not clearly defined, since many plasterers are also masons, or bricklayers, while others are whitewashers or paper hangers. The English vital statistics combine plasterers, whitewashers, and paper hangers.

The health conditions in this trade were commented upon by Ramazzini, who, in the quaint language of the day, states that "Lime and Plaister are likewise offensive to those who burn them or handle them, or sell them," and he continues: "I have frequently observed that those who boil, prepare, grind, sift, or sell it, do usually labor under a difficulty of breathing." As a safeguard, Ramazzini points out that: "Though such workmen have a cover for their mouth, they can not avoid receiving the flying particles at the mouth and nose, upon which these particles enter the passages of respiration and mix with the lymph, rise up in hard, chalky concretions, or by daubing the winding passages of the lungs intercept freedom of breath. I found," he observes, "that such as continued in this business did die asthmatic and cachetik." He refers also to a still earlier author, Morton, who connected the inhalation of the dust with consumption of the lungs. He concludes his observations with the statement that: "Care must be taken to observe the caution laid down above, with intent to guard the mouth as much as possible from receiving the offensive particles." All this was written more than two hundred years ago.

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[a] How widely qualified opinions differ with regard to the health-injurious effects of mineral dust derived from lime and cement is made evident by the following quotation from the Journal of the American Medical Association, December 12, 1908:

> Selkirk has investigated a general opinion among lime workers that they are exceptionally free from bronchitis and pulmonary tuberculosis. He was unable to find an instance of phthisis among them, nor could he learn on inquiry of any worker in limekilns having died from tuberculosis. He asks whether those who inhale and swallow much lime are abnormally free from tuberculosis of the lungs. He discusses what is known of the therapeutics of calcium salts, and says it appears that the continued absorption of calcium from the lungs and intestines might maintain an abnormally high percentage of it in the blood. He suggests that the workingman predisposed to tuberculosis might turn his attention to lime and cement working as an occupation, and even hints at the organization of lime works as a curative tuberculosis colony. A rapid increase of weight is commonly observed in new workers at the Warren Cement Works at Hartlepool.

Thackrah, writing in 1832, took a more favorable view of the employment, holding that bricklayers and their laborers, while particularly exposed to lime dust, suffered from diseases of the eye and cutaneous eruptions, but not from internal disease, and he quotes an adage common to the workmen in the trade of the period, that "bricklayers and plasterers' laborers, like asses, never die." Regarding plasterers and whitewashers, who are also exposed to lime dust, he states: "They suffer from no sensible injury," and that "they are more pallid and less robust than bricklayers." Thackrah, however, did not sustain his observations by trustworthy data.

In Rhode Island during the ten years ending with 1906, the number of recorded deaths of plasterers from all causes was 25, and of this number 5, or 20 per cent, were from consumption, and 4, or 16 per cent, from other respiratory diseases. Of the total mortality 9, or 36 per cent, were from diseases of the lungs and air passages.

The most recent English mortality statistics of plasterers and paper hangers are for the three years ending with 1902, referred to in the Supplement to the Sixty-fifth Annual Report of the Registrar-General, in part as follows:

> Between the ages of 35 and 65 years the death rate in this industry exceeds the standard for occupied and retired males, while at ages outside these limits the rates are below it. In the main working period of life the comparative mortality figure is 1,018, or within 1 per cent of the standard. The mortality from alcoholism and liver disease, from phthisis, from respiratory diseases, and from cancer, slightly exceeds the standard, and except that these workers appear to suffer but little from influenza, the figures for other diseases agree closely with the average.

The English occupation mortality statistics for plasterers are somewhat impaired in value by the fact that paper hangers and whitewashers are combined with this occupation, but the statistics may safely be accepted as indicating with approximate accuracy the specific disease liability of men in this employment to consumption and respiratory diseases. In the table which follows the mortality from all causes among men in this group is compared with that of occupied males generally, and the result is rather suggestive of conditions in this trade more or less unfavorable to life and health. The excess in the general mortality is most marked at ages 35 to 64, when the death rate of plasterers from all causes exceeds the mortality of occupied males generally by from 1.30 to 1.52 per 1,000. The mortality of plasterers, however, is below the average at ages under 35, and at 65 years or over.

MORTALITY FROM ALL CAUSES AMONG **PLASTERERS, PAPER HANGERS, AND WHITEWASHERS,** COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 for all occupied males.	Death rate for plasterers, paper hangers, and whitewashers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	2.44	1.52	− 0.92	62
20 to 24 years	4.41	3.44	− .97	78
25 to 34 years	6.01	4.07	− 1.94	68
35 to 44 years	10.22	11.52	+ 1.30	113
45 to 54 years	17.73	19.18	+ 1.45	108
55 to 64 years	31.01	32.53	+ 1.52	105
65 years or over	88.39	72.18	−16.21	82

The preceding table is self-explanatory and requires no further comment, except that it confirms the view that the health-injurious effects of this employment are not as pronounced as in many other dusty trades, but in particular such occupations as stonecutting, pottery manufacture, glass blowing, etc. In the table which follows the mortality of plasterers from consumption is compared with the normal mortality of occupied males from this disease by divisional periods of life. The comparison shows that the mortality from consumption is above the normal at ages 35 or over, but it is only at ages terers is set forth in detail in the table below:

MORTALITY FROM CONSUMPTION AMONG **PLASTERERS, PAPER HANGERS, AND WHITEWASHERS,** COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Mortality from consumption.			
	Death rate per 1,000 for all occupied males.	Death rate for plasterers, paper hangers, and whitewashers.		
		Rate per 1.000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	0.54	0.41	−0.13	76
20 to 24 years	1.55	1.06	− .49	68
25 to 34 years	2.03	1.22	− .81	60
35 to 44 years	2.74	3.98	+1.24	145
45 to 54 years	3.04	3.62	+ .58	119
55 to 64 years	2.16	4.01	+1.85	186
65 years or over	1.11	1.53	+ .42	138

The recorded industrial insurance mortality statistics of plasterers include 577 deaths from all causes, of which 136, or 23.6 per cent, were from consumption. Of the mortality of plasterers from respiratory diseases other than consumption, 67 were from pneumonia, 5 from asthma, 14 from bronchitis, and 7 from less frequent respiratory diseases. If the deaths from consumption and from other respiratory diseases are combined, 39.7 per cent of the mortality of plasterers was from diseases of the lungs and air passages. The excess in the consumption mortality of plasterers is still more clearly brought out in the tabular presentation of the proportionate mortality from this disease by divisional periods of life. While the consumption mortality was excessive at all ages under 65, the excess was most pronounced at ages 25 to 34, when out of every 100 deaths from all causes 44.9 were from consumption, against a normal expected proportion of 31.3. The analysis of the consumption mortality of plasterers is set forth in detail in the table below:

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG **PLASTERERS**, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for plasterers from experience of an industrial insurance company; figures for males in registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of plasterers, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Plasterers.	Males in registration area, 1900 to 1906.
15 to 24 years	25	7	28.0	27.8
25 to 34 years	78	35	44.9	31.3
35 to 44 years	107	38	35.5	23.6
45 to 54 years	127	35	27.6	15.0
55 to 64 years	121	16	13.2	8.1
65 years or over	119	5	4.2	2.7
Total	577	136	23.6	14.8

The preceding observations and statistical data, including the industrial insurance mortality experience of this occupation, would seem to confirm the conclusion that this employment is injurious to health, and that the degree of consumption frequency is above the average at all ages under 65, and decidedly so at ages 25 to 34.

PAPER HANGERS.

Paper hangers, equally with plasterers, are exposed to a considerable risk of mixed-dust inhalation, chiefly of mineral origin. During the operation of removing old wall paper from the walls a large amount of dust is created, against which practically no precautions are taken and no effort is made to reduce the dust to a minimum. Since wall paper often, if not as a rule, contains colored pigments more or less injurious to health and occasionally poisonous metallic substances, such as arsenic, there is an additional risk to health from this source which occasionally has assumed serious proportions. It would seem that a rational health administration should intervene to compel a previous disinfection of premises in which consumptives have died before the same are permitted to be redecorated by plasterers or paper hangers.

In Rhode Island during the 10 years ending with 1906 the number of recorded deaths of paper hangers from all causes was only 14, but of these 3, or 21.4 per cent, were from consumption, and 3, or 21.4 per cent, from other respiratory diseases. Of the total recorded mortality 6, or 42.8 per cent, were from diseases of the lungs and air passages.

The recorded industrial insurance mortality statistics of paper hangers include 319 deaths from all causes, of which 107, or 33.5 per cent, were from consumption. Of the deaths of paper hangers from other respiratory diseases, 30 were from pneumonia and 8 from other diseases of this class. The mortality of paper hangers from consumption was excessive at ages 15 to 44, but most so at ages 35 to 44, when of the deaths from all causes 44.6 per cent were from this disease, against a normal expected proportion of 23.6. The following table analyzes the consumption mortality of paper hangers:

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG **PAPER HANGERS,** 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for paper hangers from experience of an industrial insurance company; figures for males in registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of paper hangers, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Paper hangers.	Males in registration area, 1900 to 1906.
15 to 24 years	33	14	42.4	27.8
25 to 34 years	96	47	49.0	31.3
35 to 44 years	74	33	44.6	23.6
45 to 54 years	55	8	14.5	15.0
55 to 64 years	34	4	11.8	8.1
65 years or over	27	1	3.7	2.7
Total	319	107	33.5	14.8

There are no official vital statistics of paper hangers as a class separate and distinct from plasterers and similar occupations, and the only source of accurate information regarding the degree of consumption frequency among men in this employment is the industrial insurance mortality statistics, briefly referred to above.

When the insurance mortality statistics of paper hangers are compared with those of plasterers, the statistical evidence appears to be conclusive that the degree of consumption frequency among paper hangers is decidedly higher than the corresponding degree of consumption frequency among plasterers. While at all ages the proportion of deaths from consumption was 23.6 per cent for plasterers, it was 33.5 for paper hangers; at ages 15 to 24 the respective consumption percentages were 28.0 for plasterers against 42.4 for paper hangers; at 25 to 34, 44.9 per cent for plasterers and 49.0 per cent for paper hangers; at 35 to 44, 35.5 per cent for plasterers against 44.6 per cent for paper hangers. At ages 45 or over the percentages were more favorable to paper hangers than to plasterers.

Summarizing the rather limited amount of statistical information regarding the mortality of paper hangers, the available data would seem to warrant the conclusion that the degree of consumption frequency in this occupation is decidedly excessive at ages under 45 when comparison is made with occupied males generally and the occupation of plasterers in particular.

FOUNDRYMEN AND MOLDERS.

Foundrymen and molders are to a very considerable degree exposed to the continuous inhalation of both metallic and mineral dusts. While the proportion of metallic dust is quantitatively small, it is probably the more injurious of the two, although its effects are modified by the relatively much larger amount of mineral dust. The industry is varied, of large extent, and widely distributed throughout the country. The conditions affecting health naturally vary, and chiefly so on account of the metal used in casting, which may be iron, steel, brass, etc. The employments in foundry practice are chiefly those of molders and clay mixers, of which molders, again, are subdivided into those who work at a bench, or in the making of small ware, and those who work on the floor or in the pits in the making of castings of larger size. Within recent years labor-saving appliances have been extensively introduced into the large foundries, chiefly in connection with iron and steel works, but corresponding progress has not been made in the smaller establishments. The introduction of machinery has led to the employment of much unskilled labor of low grade, which complicates the value of the available mortality returns. It is also necessary to take into consideration the not inconsiderable accident liability of men employed in foundries, and the occasional or general exposure to extreme heat and the liability to overstrain inseparable from the lifting of heavy weights of metal.

An investigation into the sanitary aspects of this employment made by the state board of health of Massachusetts disclosed the fact that at fourteen foundries in which castings of all kinds were made, in seven the conditions as to light, ventilation, and dust removal were very poor. Of nine stove foundries inspected, four presented moderately bad and one distinctly bad conditions affecting the health of employees. In the polishing room of one factory, conducted under almost ideal conditions, the emery wheels were well equipped with hoods and exhaust ventilators, but the report states that "the men, unmindful of the protection provided, habitually remove the hoods, and become covered with emery and iron particles."

In reporting in some detail upon the establishments found to be more or less unsatisfactory as to light, ventilation, and dust removal, the report states that one shop "employs 275 men, in low-studded, poorly lighted, unventilated buildings, in which there is no attempt to remove the dust arising from the processes of polishing and buffing by hoods and exhaust ventilation. In the tumbling room the dust is so thick that objects a few feet distant can not clearly be made out. Many men refuse to work in this establishment in the hot months, on account of the excessive heat and general discomfort."

The vital statistics of this group of employments are not conclusive. In Rhode Island 157 deaths of molders have been recorded during the period 1897 to 1906, and of this number 31, or 19.7 per cent, were from consumption, 21 were from pneumonia, and 4 were from asthma and bronchitis, a total of 35.6 per cent of the mortality from all causes from diseases of the lungs and air passages. Respiratory diseases other than consumption are shown to have been of about the same degree of relative frequency as consumption.

The high mortality of foundrymen and molders from consumption observed to occur at advanced ages is decidedly suggestive. Evidently the progress of the disease in these occupations is slow, and often, if not as a rule, assumes the form of fibroid phthisis. There can be no question of doubt that there is in these occupations an intimate connection between the continuous exposure to metallic and mineral dust inhalation and the relative frequency of the disease. Considering the nature of the dust inhaled, this is what would be expected. The dust being largely mineral, but partly metallic, the proportion of iron dust, while quite considerable, is not so great in quantity as the iron dust inhaled by men engaged in cutlery grinding or file cutting. No doubt many of the dangers of the employment could be guarded against by attention to safety devices, chiefly respirators, to be worn during the actual mold-making processes. The employment, by its very nature, however, precludes very radical methods of dust prevention, and the most effective safeguard would be short hours of labor and a rational use of spare hours and vacations.

There are no official vital statistics of these occupations either for the United States or for England and Wales. The recorded industrial insurance mortality statistics of foundrymen and molders are very extensive and include 1,397 deaths from all causes, of which 311, or 22.3 per cent, were from consumption. Of the deaths of foundrymen and molders from respiratory diseases other than consumption, 14 were from asthma, 21 from bronchitis, 211 from pneumonia, and 31 from other diseases of this class. If the deaths from consumption and from other respiratory diseases are combined, 42.1 per cent of the mortality of foundrymen and molders was from diseases of the lungs and air passages. The mortality of foundrymen and molders was excessive at all ages over 25, but the excess was most pronounced at ages 25 to 34, when out of every 100 deaths of foundrymen from all causes, 40.4 were from consumption, against a normal expected proportion of 31.3. The analysis of the consumption mortality of foundrymen and molders in detail is set forth in the following table:

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG **FOUNDRYMEN AND MOLDERS**, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for foundrymen and molders from experience of an industrial insurance company; figures for males in registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of foundrymen and molders, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Foundrymen and molders.	Males in registration area, 1900 to 1906.
15 to 24 years	122	29	23.8	27.8
25 to 34 years	228	92	40.4	31.3
35 to 44 years	300	82	27.3	23.6
45 to 54 years	292	65	22.3	15.0
55 to 64 years	239	27	11.3	8.1
65 years or over	216	16	7.4	2.7
Total	1,397	311	22.3	14.8

The preceding observations and statistical data, derived chiefly from industrial insurance mortality experience, seem to confirm the conclusion that this employment is more or less injurious to health, and that the degree of consumption frequency is excessive at ages 25 or over.

CORE MAKERS.

Core making is an essential branch of foundry practice. The occupation gives employment to a considerable number of young persons, mostly boys, but of late years girls have been drawn into the trade, although it is held that the more arduous duties and surrounding conditions of the occupation are unsuited to the female sex. No qualified investigation appears to have been made into the health conditions of this employment, but in a general way the conditions approximate those of foundry practice in general. There is a considerable exposure to both mineral and metallic dust, but the fact that large numbers follow this occupation for only a comparatively short time no doubt prevents the more serious results which would follow if the exposure were continued for many years.

There are no official vital statistics of these occupations either for the United States or for England and Wales. The recorded industrial insurance mortality statistics of core makers include 162 deaths from all causes, of which 48, or 29.6 per cent, were from consumption. Of the mortality of core makers from respiratory diseases other than consumption, 24 were from pneumonia and 4 were from other diseases in this group. If the deaths from consumption and from other respiratory diseases are combined, 46.9 per cent of the mortality of core makers was from diseases of the lungs and air passages. The excess in the mortality from consumption falls almost exclusively upon ages under 45, since comparatively few deaths have occurred at ages 45 or over. The analysis of the consumption mortality of core makers is set forth in detail in tabular form below:

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG **CORE MAKERS**, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for core makers from experience of an industrial insurance company; figures for males in registration area computed from mortality statistics of United States census.]

Age at death.	Deaths of core makers, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Core makers.	Males in registration area, 1900 to 1906.
15 to 24 years	66	20	30.3	27.8
25 to 34 years	42	17	40.5	31.3
35 to 44 years	25	9	36.0	23.6
45 to 54 years	9	1	11.1	15.0
55 to 64 years	9	1	11.1	8.1
65 years or over	11	....	....	2.7
Total	162	48	29.6	14.8

While statistical information regarding persons employed as core makers is very limited, the evidence is entirely conclusive that the degree of consumption frequency in this occupation is decidedly excessive at ages 15 to 44, inclusive.

LITHOGRAPHERS.

Lithographers constitute an important branch of the printing trade. In the census reports lithographers are included in the occupation statistics of printers and pressmen, so that the actual number of lithographers in the United States is not known. For hygienic reasons the employment of the lithographer requires to be considered separately from printing and engraving, since in the former the exposure is chiefly to mineral dust, while the latter are exposed primarily to the inhalation of metallic dust. Lithographic stone has been defined as a fine, compact homogeneous limestone, practically all of which is imported from Germany. The small amount of lithographic stone quarried in the United States varies in its mineral and metallic constituents from the Bavarian stone, containing nearly 7 per cent of magnesia. No accurate observations have been made a matter of record to determine the degree of possible lung injury resulting in the case of the lithographer's occupation, but it is safe to assume that the employment requires to be included in the group of dusty trades. This conclusion is fully sustained by a knowledge of the technical processes which constitute the lithographic art.

The sanitary conditions of this employment received consideration by Sir John Simon in his report as medical officer of the privy council. Simon called attention to the dust resulting from the use of colors and pigments, against the inhalation of which only very few of the workmen had adopted intelligent precautions. The most pernicious of the mineral colors employed in connection with lithography were emerald green and bronze. Simon did not connect the inhalation of this dust with the occurrence of phthisis, but the inference would seem warranted that such a connection exists, at least in exceptional cases.

Parry, in his treatise on Risks and Dangers of Various Occupations, confirms this earlier opinion, and holds that in lithographing green arsenical pigments are used, the poisonous dust of which is inhaled and conveyed to the stomach. It is evident that the poisonous character of the colors or pigments is a more serious factor than the less injurious dust of the stone itself, but how far either form of dust increases the liability to consumption has not been determined.

The most recent English mortality statistics of lithographers are for the three years ending with 1902, referred to in the Supplement to the Sixty-fifth Annual Report of the Registrar-General (p. lix) in part as follows:

> At all ages except 20 to 25 and 45 to 55 the death rates among these workers exceed the standard for all occupied and retired males. These workers experience a lower mortality than printers up to the age of 45, but beyond that age the mortality in the two occupations differs but slightly. In the main working period of life the comparative mortality figure of lithographers is 964, or 4 per cent, below the average. Their mortality from influenza and phthisis considerably exceeds the standard, while that from respiratory diseases is below it by about an equal amount.

The English mortality statistics for lithographers are rather inconclusive as to a decidedly unfavorable effect of this industry on health, and while in the table which follows a comparison is made of the mortality from all causes of men in this group with occupied males generally, the death rates are, as a rule, below the average for occupied males generally except at ages 20 to 24 and 45 to 54, inclusive.

MORTALITY FROM ALL CAUSES OF **LITHOGRAPHERS**, COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 for all occupied males.	Death rate for lithographers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	2.44	1.55	−0.89	64
20 to 24 years	4.41	5.36	+ .95	122
25 to 34 years	6.01	5.62	− .39	94
35 to 44 years	10.22	8.41	−1.81	82
45 to 54 years	17.73	19.94	+2.21	112
55 to 64 years	31.01	30.84	− .17	99
65 years or over	88.39	82.25	−6.14	93

The preceding table is self-explanatory and requires no further comment, but a more extended comparison, however, is made in the next table, in which the mortality of lithographers from consumption is compared with the normal mortality of occupied males from this disease, by divisional periods of life. This table shows that the mortality of lithographers from consumption was above the average at all ages by from 0.23 to 2.17 per 1,000. The excess is not very marked and does not warrant decidedly unfavorable conclusions. The table which follows requires no further comment and is otherwise self-explanatory.

MORTALITY FROM CONSUMPTION AMONG **LITHOGRAPHERS**, COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Mortality from consumption.			
	Death rate per 1,000 for all occupied males.	Death rate for lithographers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	0.54	0.77	+0.23	143
20 to 24 years	1.55	2.68	+1.13	173
25 to 34 years	2.03	2.70	+ .67	133
35 to 44 years	2.74	3.13	+ .39	114
45 to 54 years	3.04	4.27	+1.23	140
55 to 64 years	2.16	4.33	+2.17	200
65 years or over	1.11	1.44	+ .33	130

The recorded industrial insurance mortality statistics of lithographers include 160 deaths from all causes, of which 70, or 43.8 per cent, were from consumption. Of the mortality of lithographers from respiratory diseases other than consumption, 3 were from bronchitis, 18 from pneumonia, and 1 from another disease of this class. If the deaths from consumption and from other respiratory diseases are combined, 57.5 per cent of the mortality of lithographers was from diseases of the lungs and air passages. The number of deaths of lithographers included in this analysis is sufficiently large to warrant a more definite conclusion than the corresponding general vital statistics of this occupation for England and Wales. The excess in the consumption mortality of lithographers is still more clearly brought out in the tabular presentation of the proportionate mortality from this disease, by divisional periods of life. The comparison shows that the consumption mortality was excessive at all ages under 65, but decidedly so at ages 15 to 34. At 15 to 24 the proportion of deaths from consumption among lithographers was 56.8 per cent against a normal expected proportion of 27.8, while at ages 25 to 34 the proportionate consumption percentage was 62.2 for lithographers against a normal expected proportion of 31.3. The analysis of the consumption mortality of lithographers is set forth in detail in the following table:

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG **LITHOGRAPHERS**, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for lithographers from experience of an industrial insurance company; figures for males in registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of lithographers, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Lithographers.	Males in registration area, 1900 to 1906.
15 to 24 years	37	21	56.8	27.8
25 to 34 years	45	28	62.2	31.3
35 to 44 years	29	13	44.8	23.6
45 to 54 years	21	5	23.8	15.0
55 to 64 years	18	3	16.7	8.1
65 years or over	10	....	....	2.7
Total	160	70	43.8	14.8

The preceding observations and statistical data confirm the conclusion that lithographers as a class are subject to an excessive mortality from consumption, but in particular at ages 15 to 44, and this excess, in view of the conditions of labor briefly described, is in a large measure the result of health-injurious circumstances connected with the employment.

SUMMARY OF CONCLUSIONS REGARDING OCCUPATIONS WITH EXPOSURE TO MINERAL DUST.

In the foregoing observations and statistical data twelve occupations, involving exposure to mineral dust, have been considered in detail. As stated in the summary of conclusions regarding occupations with exposure to metallic dust, it is not possible in all cases to base conclusions upon identical data, as official vital statistics are not available for some of the occupations here considered. The census returns of 1900 give the age distribution of marble and stone cutters, glass workers, potters, plasterers, and paper hangers, the aggregate number of such persons being 168,404. This number is exclusive of persons under 15 and of unknown ages. The statistics show that only 4,409, or 2.6 per cent, had attained to an age of 65 years or over, against a normal expected proportion of 4.7. This fact in itself is decidedly suggestive of conditions more or less unfavorable to health and life in occupations exposing to mineral dust. The details of the age distribution are given in the following table by divisional periods of life, together with the corresponding distribution of all occupied males, the data for both groups being derived from the census of 1900.

NUMBER AND PER CENT OF MALES IN EACH AGE GROUP IN **OCCUPATIONS EXPOSED TO MINERAL DUST,** COMPARED WITH NUMBER AND PER CENT IN ALL OCCUPATIONS IN THE UNITED STATES, 1900.

[From report of the Bureau of the Census on Occupations, 1900.]

Age.	Males in occupations exposed to mineral dust.		All occupied males.	
	Number.	Per cent.	Number.	Per cent.
15 to 24 years	40,454	24.0	5,933,720	26.0
25 to 34 years	49,987	29.7	5,993,847	26.3
35 to 44 years	38,253	22.7	4,704,682	20.6
45 to 54 years	24,784	14.7	3,250,259	14.3
55 to 64 years	10,517	6.3	1,856,181	8.1
65 years or over	4,409	2.6	1,063,856	4.7
Total	168,404	100.0	22,802,545	100.0

According to this analysis, the proportion of persons aged 15 to 34 was 53.7, or more than half of the total, against 52.3 expected. At ages 35 to 44 the proportion was 22.7 for the group under consideration, against 20.6 among occupied males generally. At ages 45 or over the proportion of persons employed in occupations with exposure to mineral dust was only 23.6, against 27.1 for occupied males generally. In some of the trades included in this group a considerable amount of muscular labor is involved, and this is especially true of glass blowers and certain occupations in the pottery industry. It is, doubtless, for this reason that the age distribution in this group of employments conforms somewhat more to that of all occupied males than was true of the occupations in the group exposed to metallic dust.

It is possible to present a combined summary of the United States census vital statistics of persons employed as marble and stone cutters, glass workers, and plasterers. A comparison of the death rates in these combined occupations with the corresponding death rates of occupied males generally is very suggestive of unfavorable health conditions in occupations exposed to mineral dust. These unfavorable health conditions manifest themselves in an increased mortality at all ages above 25, while at ages 15 to 24 the mortality rate from all causes is slightly more favorable for the occupations in this group than for occupied males generally. The number of deaths, however, in the earlier age groups is too small to warrant final conclusions. At ages 25 to 44 the death rate from all causes in the occupations of this group was 9.88, against 8.78 expected; at ages 45 to 64 the death rate in the group under consideration was 24.04, against 19.91 expected; and at ages 65 or over the rate was 106.87, against 98.44 expected. The death rate from consumption was 4.87 per 1,000, against 2.37 expected, and the death rate from other respiratory diseases was 1.99, against 1.97 expected. The details of the mortality by ages are given in the following table, together with the corresponding death rates for all occupied males, the data for both groups being derived from the census of 1900:

MORTALITY FROM ALL CAUSES AMONG MALES IN **OCCUPATIONS EXPOSED TO MINERAL DUST** IN THE REGISTRATION STATES, COMPARED WITH THAT OF ALL OCCUPIED MALES IN THOSE STATES, 1900, BY AGE GROUPS.

[From report of the Bureau of the Census on Vital Statistics, 1900.]

Age.	Males in occupations exposed to mineral dust.			All occupied males.		
	Number employed.	Number of deaths from all causes.	Rate per 1,000 from all causes.	Number employed.	Number of deaths from all causes.	Rate per 1,000 from all causes.
15 to 24 years	8,724	39	4.47	1,259,471	6,486	5.15
25 to 44 years	24,506	242	9.88	2,680,241	23,541	8.78
45 to 64 years	9,899	238	24.04	1,282,259	25,532	19.91
65 years or over	1,179	126	106.87	283,310	27,888	98.44
Total	44,308	645	[a] 14.56	5,505,281	83,447	[b] 15.16

[a] From consumption there were 216 deaths, or a rate of 4.87; from other diseases of the respiratory system there were 88 deaths, or a rate of 1.99.

[b] The rate of mortality from consumption was 2.37; from other diseases of the respiratory system 1.97.

The occupation mortality statistics of Rhode Island are available for four specific occupations of this group and when combined return 321 deaths from all causes, of which 79 were from consumption and 53 from respiratory diseases other than consumption. The corresponding percentages were 24.6 of deaths from consumption for persons employed in occupations with exposure to mineral dust, against 17.8 for occupied males generally in the State of Rhode Island. The percentage of deaths from respiratory diseases other than consumption was 16.5 for the occupations in this group, against 12.5 expected.

The English vital statistics for this group of occupations are available for glass workers, potters, paper hangers and plasterers, and lithographers. When the returns for these occupations are combined they exhibit excessive death rates at all ages over 35.

The details in tabular form are set forth in the following table:

MORTALITY FROM ALL CAUSES, FROM CONSUMPTION, AND FROM OTHER RESPIRATORY DISEASES IN **OCCUPATIONS EXPOSED TO MINERAL DUST**, COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 due to all causes among—		Death rate per 1,000 due to consumption among—		Death rate per 1,000 due to other diseases of the respiratory system among—	
	All occupied males.	Occupations exposed to mineral dust.	All occupied males.	Occupations exposed to mineral dust.	All occupied males.	Occupations exposed to mineral dust.
15 to 19 years......	2.44	2.35	0.54	0.55	0.24	0.27
20 to 24 years......	4.41	4.02	1.55	1.44	.48	.50
25 to 34 years......	6.01	5.24	2.03	2.01	.77	.78
35 to 44 years......	10.22	12.46	2.74	3.96	1.66	2.12
45 to 54 years......	17.73	23.74	3.04	4.91	3.32	6.05
55 to 64 years......	31.01	40.23	2.16	3.94	6.54	12.86
65 years or over...	88.39	92.60	1.11	1.13	17.77	24.50

The table shows that the mortality from consumption among men in occupations with exposure to mineral dust was decidedly excessive at ages 35 to 64, and the mortality at the other ages was not appreciably lower than for occupied males generally. The mortality from respiratory diseases other than consumption was normal in this group of employments at ages 15 to 34, but at ages 35 or over the mortality was considerably in excess of that for all occupied males.

The recorded industrial insurance mortality statistics are available for 11 occupations included in this group, returning in the aggregate 4,543 deaths from all causes. Of this number 1,299, or 28.6 per cent, were from consumption. The deaths from other respiratory diseases numbered 762, or 16.8 per cent. The expected consumption mortality on the basis of the mortality among males in the registration area of the United States for the seven-year period 1900 to 1906 was 14.8 per cent, and from respiratory diseases other than consumption 11.7 per cent. When the mortality from consumption and from other respiratory diseases is combined, the proportionate number of deaths among males in occupations with exposure to mineral dust was 45.4 against 26.5 per cent expected.

PROPORTIONATE MORTALITY FROM CONSUMPTION IN **OCCUPATIONS EXPOSED TO MINERAL DUST**, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for occupations exposed to mineral dust from experience of an industrial insurance company; figures for males in registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths in occupations exposed to mineral dust, 1897 to 1906, due to—		Per cent of deaths due to consumption in—	
	All causes.	Consumption.	Occupations exposed to mineral dust.	Males in registration area 1900 to 1906.
15 to 24 years	413	131	31.7	27.8
25 to 34 years	821	391	47.6	31.3
35 to 44 years	936	340	36.3	23.6
45 to 54 years	950	265	27.9	15.0
55 to 64 years	795	129	16.2	8.1
65 years or over	628	43	6.8	2.7
Total	4,543	[a] 1,299	[a] 28.6	[b] 14.8

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[a] There were also 762 deaths from other diseases of the respiratory system, or 16.8 per cent of the deaths from all causes.

[b] The per cent of deaths from other diseases of the respiratory system in the registration area was 11.7.

It is evident from the foregoing observations and statistical data relating to a representative number of employments with exposure to mineral dust that the health-injurious effects of such exposure reveal themselves in a high general death rate, especially at ages 35 or over, and with correspondingly high specific death rates from consumption and from other respiratory diseases at ages 35 or over, by which time the dust inhaled has begun to show its fatal effect.

OCCUPATIONS WITH EXPOSURE TO VEGETABLE FIBER DUST.

In the group of occupations exposing to a continuous and considerable inhalation of vegetable fiber dust resulting from industrial processes the following representative employments have for the present purpose been included: Cotton ginning, cotton textile manufacture, spinning, weaving, hosiery and knitting mills, lace making, flax and linen manufacture, hemp and cordage manufacture, manufacture of jute and jute goods, paper manufacture, cabinetmaking, wood turning and carving. These occupations are all more or less subject to an excessive death rate from all causes, but in particular to a decided excess in the proportionate mortality from consumption, and in most cases also to a comparatively high degree of frequency in the occurrence of other respiratory diseases. The details of labor conditions as far as they could be conveniently included in the following summary of observations regarding particular trades appear to fully confirm the opinion that the degree of excess in consumption frequency is intimately related and in almost exact proportions to the degree of exposure to continuous and considerable inhalation of vegetable fiber dust.

COTTON GINNING.

Cotton ginning is the most important preliminary process in cotton manufacture, and is carried on extensively as a separate industry throughout the Southern States. The process consists of "stripping the fiber of cotton from the seed" by a most ingenious mechanical device, the best known of which is the so-called McCarthy machine, in common use throughout the United States.([a]) An improvement, however, has been perfected, known as the so-called "saw gin," which has the decided advantage of a material increase in producing capacity. The object being to secure the largest amount of lint, or clean cotton, it is remarkable that from every ton of raw cotton only about 600 pounds reach the spinner. The amount of dust and dirt generated in the ginning process is, of necessity, very large, and the employment is, without question, decidedly detrimental to health. It is mitigated by the fortunate circumstance that it is carried on, as a rule, only for a portion of the year, and largely because of this fact the health conditions of the occupation have not attracted so much attention as would otherwise have been the case.

The enormous extent of the cotton-ginning industry is measured by the number of bales of cotton ginned during 1904, when the crop attained to 13,500,000 bales which, at 500 pounds each, represent 6,750,000,000 pounds of cotton passing through the gins. Most of the cotton is short staple, only about 1 per cent being Sea Island or long staple variety. The gins are either public or private establishments or merchant gins, all of which, however, have the essential features in common. They are now practically all run by steam power, the former use of horse or water power having almost disappeared. A ginnery includes three departments; that is, the ginhouse proper, the lint room, and the cotton compress, or screw, as it is usually known. In an early description of the conditions in the lint room, as a part of the United States census report on cotton manufacture for 1880, it was stated that—

> The lint room varies in size from one-third to the full length of the end of the ginhouse to which it is attached. The lint cotton is thrown by the brush cylinder of the gin through a flue into this room. Strange to say, the lint rooms are not brushed or swept out from one season to another, or from one decade to another, for that matter. The dirt may accumulate an inch in depth on the floors and walls, but no broom is ever carried into this room from year to year.([b])

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[a] For an instructive and valuable descriptive account, see the Scientific American Supplement for April 1, 1905. See also Census Bulletin No. 97, on Supply and Distribution of Cotton, for the year ending August 31, 1908.

[b] Report of the Tenth Census, Vol. II, p. 945.

The ginning process itself is well described in an account of the so-called Gullett cotton-ginning system, which is in general use throughout the Southern States:

> The seed cotton is elevated by suction from the wagon or storage house, and deposited in feeders over each gin. These machines feed it uniformly into the roll boxes of gins, where the lint is separated from the seed. The lint is then blown by the draft from the brush through the flue system into the condenser, which forms it into a bat and deposits it direct in the press, where it is packed by the steam packer and baled, the dust from the condenser passing out through the roof by means of the dust flues. The seed falls from the roll boxes of gins into a screw conveyor underneath, through hoppers at each gins, however, the earlier conditions still prevail, and the dust nuisance during the ginning process constitutes a serious menace to the health of the employees.

The claims for this system are economy of time and labor and the material reduction of the dust nuisance. In the large majority of gins, however, the earlier conditions still prevail, and the dust nuisance during the ginning process constitutes a serious menace to the health of the employees.

The hygienic aspects of the sanitary problems in cotton ginning were early commented upon by Daniel Drake, M. D., in his treatise on the Principal Diseases of the Interior Valley of North America, where, in considering the miscellaneous causes of pulmonary inflammation, with special reference to the Southern States, he comments upon cotton fuzz and its effects upon the respiratory organs, referring in particular to employment in cotton gins. According to Drake—

> The gin is a machine of rapid motion for eliminating the seed from cotton. It throws an immense amount of broken fibers or fuzz into the atmosphere, which are of necessity taken into the lungs of those who conduct the operation, who are generally Negroes. The period of ginning does not last very long, nor are a great number of operatives necessary to the management of a gin. When traveling in the South, I learned that proprietors do what they can to promote ventilation, avoid their ginhouses, and avoid employing men who are predisposed to pulmonary disease, and often change them, so that no one shall inhale the fuzz very long. These precautions indicate, as the public opinion, that it may do harm, as indeed it undoubtedly does, but to a less extent than might perhaps be expected.(a)

The observations of Drake as to the health-injurious effects of the cotton-ginning process were confirmed by other practicing physicians of the period and the earlier view is sustained by present-day medical opinion throughout the South. Since there are no vital statistics of persons employed in cotton ginning and no published observations of medical practitioners at the present time, these brief observations are concluded by quoting the opinion of Mr. A. E. Thomas, a cotton planter before the war, who, with special reference to the susceptibility of the Negro, who continues to constitute the large majority of persons employed in connection with cotton-ginning processes, states that—

(a) Principal Diseases of the Interior Valley of North America, by Daniel Drake, Vol. II, p. 799.

> This subject is one of great interest with all our intelligent planters, as the effect of cotton ginning on their Negroes is very deleterious; so injurious, indeed, as to be obvious to the Negroes themselves, who endeavor to avoid the ginhouse. Planters select their oldest and least valuable Negroes for this occupation, knowing that the healthiest and most robust will, in a year or two, become diseased. To prevent these bad effects, it is not uncommon to make them wear and breathe through a veil, and give them molasses and water to drink, measures which appear to be generally effective. If a person not accustomed to breathe the air of a ginhouse goes into it while the machine is running, he is soon seized with a tickling sensation in his nostrils, followed by sneezing, coughing, and some degree of hoarseness. Continuing awhile in this situation, he begins to feel his nostrils stuffed up. After leaving the place he will have symptoms of a cold for several days. Remaining there longer, the stuffing of his nostrils may become so great as to prevent his breathing through them. The cough attendant on this affection is often dry, or small quantities of mucus, in which the lint and dust floating in the air have been entangled, will be thrown up. A feeling of soreness pervades the trachea and bronchial tubes. I have known several to have chronic bronchitis. I saw one death preceded by the discharge of an abscess from the lungs, and another die of phthisis, following on bronchitis. It is the custom every two or three weeks to stop the hands from field labor to bale the gin and cotton, at which they are commonly occupied two or three days. Before the end of this period they are apt to become affected with sneezing, coughing, and other catarrhal symptoms, which often continue for several days. ([a])

It is evident, even in the absence of conclusive statistical data, that cotton ginning is a decidedly health-injurious employment, and that it would be much more so than actually observed in everyday experience but for the fact that the occupation extends over only a comparatively short period of the year.

COTTON TEXTILE MANUFACTURE.

In 1905 the manufacture of cotton textiles in the United States gave employment to 315,874 wage-earners, of whom 46.6 per cent were adult males, 40.6 per cent women, and 12.8 per cent children. ([b]) The diversity of the industry is considerable, and the processes of manufacture require a high degree of specialized labor. Every process from the so-called "opening" of the cotton in the picker room to the carding, spinning, and weaving involves a more or less considerable degree of exposure to the inhalation of vegetable fiber dust, but the exposure varies materially in the different departments. The health aspects of the industry are complicated by other injurious factors besides dust, of which high temperature, excessive humidity, atmospheric electricity, noise, eye strain, and defective ventilation are the most important. The effects upon health in cotton textile manufacture, with special reference to dust exposure, have been admirably summed up by Arlidge, who, in his treatise on The Hygiene, Diseases, and Mortality of Occupations, remarks:

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[a] Principal Diseases of the Interior Valley of North America, by Daniel Drake, Vol. II, p. 801.

[b] Census of Manufactures, 1905, Part I, p. lxxviii.

> To summarize the incidental causes of ill health among cotton operatives, they are, dust from the cotton itself in the early processes of manufacture; heat with more or less watery vapor, combined in the weaving department with dust from the Cornish clay employed for sizing; long standing, and a stooping posture in the spinning and doubling department; monotony of work; continuous strain upon the attention; and excessive noise with vibration of machinery. To these must be added vitiated air from excessive consumption of gas, from overcrowding, and general defects of ventilation.

With special reference to the frequent occurrence of lung diseases among cotton workers, Arlidge holds that—

> The dust of cotton is an irritant to the pharynx and larynx, where it speedily produces a feeling of dryness and huskiness. If inhaled longer, it reaches the bronchi, and sets up cough with white mucous expectoration. The cough will be for years chiefly a morning phenomenon on first rising, but it is also induced upon leaving the warm workroom. Fine fibers of cotton are found, on microscopical examination, in the sputum, and as these make their way into the pulmonary tissue, they set up morbid action, resulting in increasing density of it on the one hand, and of emphysematous expansion on the other. These morbid changes are accompanied by dyspnœa, wastings, and debility, but rarely with hæmoptysis; and together constitute a group of symptoms not inappropriately termed "industrial phthisis." Moreover, intercurrent diseases of the lungs, such as acute bronchitis and pneumonia, often arise and terminate life; and true tubercular phthisis is no uncommon cause of death.

The following is an extract from the observations of Lloyd, who confirms the observations of Arlidge in the statement that—

> The dust of cotton, or "flue" as it is called, is composed largely of cotton fiber, and it has an appreciable taste and smell, especially to a person unused to it. It causes irritation to the nose, throat, larynx, and bronchial tubes. The symptoms are dryness of the throat, huskiness of the voice, cough, and expectoration. The cough is said to be worse in the morning, the expectoration being tenacious and difficult to be gotten rid of. Fibers of cotton have been found in the sputa with the microscope. In time proliferation of connective tissue

ensues, as in most cases of industrial phthisis, and dyspnœa and emaciation occur. In many cases it is evident that a true tubercular infection takes place.

Lloyd quotes Dr. F. F. Simpson, of Spartanburg, S. C., with reference to an affection of the tonsils among cotton operatives in that State, due to the custom of sucking cotton fiber strongly into the mouth in some processes of their work, as follows:

> These fibers become encysted in the crypts of the tonsils, thus becoming a source of constant irritation, and giving rise to what in that section is not inaptly termed "weavers' tonsils."

In a report of the Massachusetts state board of health on dangerous trades a similar practice is commented upon as follows:

> A bad, unhygienic habit, common to all weavers who tend old-fashioned looms, is that of drawing the filling through the shuttle eye with the mouth. The weaver puts his mouth close to the shuttle, and, by means of a quick intake of breath, sucks the end of the thread through the shuttle eye, thus drawing into his mouth more or less fine lint and dust, which gives rise to spitting, and sooner or later may cause irritation of the mucous membrane of the throat.

It is explained that the gradual replacement of old-style looms by the Northrup loom, in which after the drum is filled with shuttles the action is entirely automatic, has eliminated this practice mechanically where persuasion and disinterested advice have been of no avail.

The general dust problem in textile factories is discussed in the same report at considerable length, and since the observations are descriptive of present-day conditions in the textile centers of New England, the remarks are quoted almost in their entirety as a most useful contribution to the knowledge of this important branch of occupation disease:

> The presence of dust in the air of workrooms is a prominent feature in its influence on health. Aside from dirt and other impurities which may be in the stock, it is the opinion of recognized medical authorities that vegetable dusts are markedly inimical to health. Those operatives in cotton mills who are peculiarly sensitive to unhygienic influences may become seriously affected through the constant irritation of cotton dust or "fly" in the upper air passages, giving rise first to dryness of the throat and later to cough and expectoration. Flax dust is thought to be even more irritating than cotton, while dust in the woolen and silk mills (animal origin) is considered to be less harmful in its effects.
>
> There are many departments in which processes are conducted which expose the employees to dust; but the weaving, spinning, carding, and waste rooms illustrate the important unhygienic conditions commonly associated with this disturbing element. In estimating the effects of dust upon health, the following considerations, among others, are to be borne in mind:
>
> 1. Grade of stock used, e. g., quality of cotton.
> 2. Quantity of dust in a given room.

3. Whether the dust is constant.
4. Type of construction of the room.
5. System of management.
6. Number and kinds of other unhygienic influences present.
7. Means of ventilation.
8. Health and susceptibility of the individual.

In some weave rooms the air is so filled with minute bits of dust as to present a hazy or "smoky" appearance throughout the room, and parts of the room are covered with the small particles which have settled thereon; while other weave rooms are practically free from such dust, there being merely a slight amount of lint or dust of microscopic fineness. Dust in ring-spinning rooms is more constant and is greater in amount than in weave rooms. In a fine-goods mill, in which a high quality of cotton is used in a properly constructed and well-regulated room, the amount of dust present is comparatively unimportant, from the point of view of health. On the other hand, in a coarse-goods mill, where waste stock is used in a low-studded and generally neglected room, the amount, constancy and character of the dust is such as to suggest the probability of real danger.

While in both weave and ring-spinning rooms there are many unhygienic factors, the principal features of the card room are (1) the amount of dust and (2) lack of proper ventilation and effective means of removing the dust. Cotton dust in the card room varies greatly both in quality and quantity. It is always considerable, owing to the carding process of freeing and cleaning the material.

In some mills it is enormous in amount, with considerable dirt as a concomitant. The quantity of dust is commonly sufficient to cause a distinct cloudiness of the atmosphere, which, in a room lacking proper ventilation, is a serious menace to the health of the operatives.

It has long been known that work which involves more or less constant confinement in a dusty atmosphere predisposes to the development of diseases of the lungs, especially of pulmonary consumption; but only in recent years, through the science of bacteriology, has the medical profession and the public been enlightened as to the specific cause of consumption, and the method of its dissemination among the susceptible. The people of to-day, therefore, in every walk of life, have a far greater responsibility thrust upon them with respect to minimizing this source of danger by the application of all reasonable sanitary measures. We have to bear in mind, then, in considering the dust problem, the possibility of the presence of "infectious dust" from dried sputum in the air of different mill rooms. Persons suffering from consumption can not always be detected in these rooms, and the habit of indiscriminate spitting involves the possibility of infection.

A comparison of the important constant or possible unhygienic influences in the ring-spinning and carding departments, with emphasis upon the dust in these rooms, is as follows:

RING SPINNING.

1. Considerable dust (constant).
2. "Infectious dust" (dried sputum).
3. Excessive heat (with artificial moisture).

4. Excessive heat (without artificial moisture in some rooms).
5. Lack of provision for a plentiful supply of fresh air.
6. Poor light.
7. Carbon monoxide gas, and excessive amounts of carbon dioxide from respiration and combustion.

CARDING.

1. Dust (abundant and continuous).
2. "Infectious dust" (dried sputum).
3. Lack of provision for a plentiful supply of fresh air.
4. Carbon monoxide gas, and excessive amounts of carbon dioxide from respiration and combustion.

There are, unfortunately, no very satisfactory or trustworthy general vital statistics of the cotton industry in the United States. The vital statistics of the census of 1890 included 1,080 deaths of male textile factory operatives, and of this number 15.4 per cent had attained to ages 65 or over. The general death rates were slightly above the average for the manufacturing class at ages 15 to 25, below at ages 25 to 65, and slightly above the average at 65 years or over. The consumption death rate for textile factory operatives was 2.27 per 1,000, or below the general average, but this in all probability was the result of defective enumeration, partly because of the crude grouping of all textile operatives as a class.

The vital statistics of the census of 1900 included 1,332 deaths of male textile operatives from all causes, and of this number 232, or 17.4 per cent, had attained to ages 65 or over. The death rates generally were below the average for males employed in manufacturing and mechanical industries, except at ages of 65 or over. Out of the 1,332 deaths from all causes, previously referred to, 313, or 23.5 per cent, were from consumption. The corresponding death rate was 2.08 per 1,000, against 2.62 for the manufacturing and mechanical class. The death rate from other respiratory diseases was 1.07 per 1,000 for textile factory operatives, against 1.81 for the manufacturing and mechanical industry class, so that for both consumption and other respiratory diseases the recorded mortality indicates a lesser liability to these diseases than is met with among occupied males in more or less similar employments. These statistics, however, can not be accepted as entirely accurate or conclusive, and they are here included only to call attention to the necessity of extreme caution in accepting the vital statistics of certain occupations where labor conditions materially interfere with the continuity of employment and where the opportunities for change from one occupation to another are rather exceptional.

The available occupation mortality statistics of Rhode Island refer to textile operatives as a class, regardless of the kind of fiber manufactured, which hardly warrants entirely safe conclusions, and the same is true of the corresponding statistics of the Twelfth Census of the United States, which groups mill and factory operatives under textiles, also without distinction of the kind of textile manufactured, such as cotton, wool, flax, jute, etc. The Rhode Island statistics for the period 1897 to 1906 include 798 deaths from all causes, and of this number 218, or 27.3 per cent, were from consumption.

In English occupation mortality statistics cotton textile operatives are combined with persons employed in the manufacture of flax and linen, which also to a certain degree impairs their value. Since the proportion of persons employed in linen and flax manufacture is comparatively small, the error is not a very serious one. In the aggregate the English data for 1890 to 1892 include the observed mortality experience of 538,077 occupied males exposed to the risk of death one year, among whom there occurred 7,471 deaths from all causes. The specific death rates have been calculated by divisional periods of life, and an instructive comparison is possible with the corresponding mortality of occupied males generally.

MORTALITY FROM ALL CAUSES AMONG MALES EMPLOYED IN THE MANUFACTURE OF COTTON, FLAX, AND LINEN, COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1890 TO 1892, BY AGE GROUPS.

[From Supplement to the Fifty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 for all occupied males.	Death rate for cotton, flax, and linen employees.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	2.55	3.55	+ 1.00	139
20 to 24 years	5.07	5.95	+ .88	117
25 to 34 years	7.29	7.17	− .12	98
35 to 44 years	12.43	12.83	+ .40	103
45 to 54 years	20.66	24.68	+ 4.02	119
55 to 64 years	36.66	52.55	+15.89	143
65 years or over	102.32	159.08	+56.76	155

The mortality of English cotton-mill operatives, including workers in linen and flax, is shown by the preceding table to have been excessive at all ages, except 25 to 34. This is probably the result of the very heavy death rate prevailing at ages under 20, and the comparatively high death rate at ages 20 to 24. The excess in the general mortality of persons employed in this occupation becomes more apparent at ages 45 to 54, and decidedly pronounced at ages 55 or over. It requires no very extended analysis of the causes of death among this class of operatives to establish the fact that the excess in the general mortality is primarily the result of a high death rate from consumption and other respiratory diseases. The facts, as far as they are obtainable from the published reports, are set forth in tabular form below, which shows the mortality rate by divisional periods of life from consumption and from respiratory diseases other than consumption among cotton mill operatives, including linen and flax, and among occupied males generally, first from consumption and second from other respiratory diseases:

MORTALITY FROM CONSUMPTION AND FROM OTHER DISEASES OF THE RESPIRATORY SYSTEM AMONG MALES EMPLOYED IN THE **MANUFACTURE OF COTTON, FLAX, AND LINEN**, COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1890 TO 1892, BY AGE GROUPS.

[From Supplement to the Fifty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Mortality from consumption.				Mortality from other diseases of the respiratory system.			
	Death rate per 1,000 for all occupied males.	Death rate for cotton, flax, and linen employees.			Death rate per 1,000 for all occupied males.	Death rate for cotton, flax, and linen employees.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years.....	0.70	1.26	+0.56	180	0.26	0.44	+ 0.18	169
20 to 24 years.....	1.95	2.86	+ .91	147	.61	.89	+ .28	146
25 to 34 years.....	2.63	2.91	+ .28	111	1.13	1.24	+ .11	110
35 to 44 years.....	3.43	3.24	− .19	94	2.50	3.41	+ .91	136
45 to 54 years.....	3.38	4.09	+ .71	121	5.15	7.71	+ 2.56	150
55 to 64 years.....	2.65	3.11	+ .46	117	10.32	18.19	+ 7.87	176
65 years or over ..	1.50	2.50	+1.00	167	25.91	53.19	+27.28	205

These earlier statistics have been included, since they will prove useful for reference and comparison with the more recently published occupation mortality data for males employed in this industry, which will subsequently be referred to in detail. The preceding table shows that the mortality from consumption among cotton workers was excessive at all ages except the period 35 to 44, when, however, the rates quite closely approach the average for occupied males generally. More significant are the pronounced differences in the mortality of cotton workers from respiratory diseases other than consumption, which is excessive at all ages and which probably includes some deaths from fibroid phthisis recorded as chronic bronchitis or chronic pneumonia, or under some similar term.

More trustworthy and conclusive are the corresponding statistics of cotton manufacture for England which have been recently made public for the three years ending with 1902 and which are referred to in the Supplement to the Sixty-fifth Annual Report of the Registrar-General, in part as follows:

> In the term of life from the twentieth to the forty-fifth year the death rates of cotton workers are below the standard for occupied and retired males; but at other ages they exceed it. In the main working

time of life the comparative mortality figure for the industry is 1,114, or 11 per cent above the standard. Cotton operatives experience an excess of about one-fourth in the mortality from nervous and respiratory diseases, and also a slight excess from cancer, phthisis, circulatory diseases, Bright's disease, and suicide. Their mortality from influenza is less than the normal; they appear to be but slightly addicted to intemperance, and their mortality figure from accident is little more than half the standard.

The English occupation mortality statistics for males employed in cotton manufacture during the three-year period 1900 to 1902 include 5,710 deaths from all causes. Of this number of deaths 1,093, or 19.1 per cent, were from consumption, and 1,084, or 19.0 per cent, from respiratory diseases other than consumption; of the deaths from all causes 2,177, or 38.1 per cent, were therefore from diseases of the lungs and air passages. In the following table a comparison is made of the mortality from all causes among men engaged in cotton manufacture with that of occupied males generally, and the result indicates an excessive mortality at ages 45 or over, and also a slightly excessive mortality at ages 15 to 19. At ages 20 to 44 the mortality among cotton workers was somewhat less than for all occupied males.

MORTALITY FROM ALL CAUSES AMONG MALES EMPLOYED IN **COTTON MANUFACTURE,** COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 for all occupied males.	Death rate for male cotton workers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	2.44	2.68	+ 0.24	110
20 to 24 years	4.41	4.32	− .09	98
25 to 34 years	6.01	5.48	− .53	91
35 to 44 years	10.22	9.61	− .61	94
45 to 54 years	17.73	20.46	+ 2.73	115
55 to 64 years	31.01	41.15	+10.14	133
65 years or over	88.39	127.31	+38.92	144

In the table which follows the mortality from consumption and from respiratory diseases other than consumption among men employed in cotton manufacture is compared with the normal mortality for all occupied males from these diseases by divisional periods of life. The comparison shows that the mortality from consumption was above the average at all ages except 25 to 34, when the mortality was practically the same for cotton workers as for all occupied males. The excess in the mortality is quite pronounced at ages 45 or over. The mortality from other respiratory diseases was somewhat excessive at all ages except 35 to 44, but the excess was most pronounced at ages 20 to 24 and at 45 or over.

MORTALITY FROM CONSUMPTION AND FROM OTHER DISEASES OF THE RESPIRATORY SYSTEM AMONG MALES EMPLOYED IN **COTTON MANUFACTURE**, COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Mortality from consumption.				Mortality from other diseases of the respiratory system.			
	Death rate per 1,000 for all occupied males.	Death rate for male cotton workers.			Death rate per 1,000 for all occupied males.	Death rate for male cotton workers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	0.54	0.82	+0.28	152	0.24	0.25	+ 0.01	104
20 to 24 years	1.55	1.65	+ .10	106	.48	.60	+ .12	125
25 to 34 years	2.03	2.01	− .02	99	.77	.81	+ .04	105
35 to 44 years	2.74	2.89	+ .15	105	1.66	1.51	− .15	91
45 to 54 years	3.04	3.66	+ .62	120	3.32	4.18	+ .86	126
55 to 64 years	2.16	2.76	+ .60	128	6.54	9.80	+ 3.26	150
65 years or over	1.11	2.13	+1.02	192	17.77	28.50	+10.73	160

Summarizing these observations and statistical data, they indicate a somewhat excessive mortality, particularly at the more advanced ages, undoubtedly due to the inhalation of vegetable fiber dust, the health-injurious effects of which are more slow to reveal themselves than when the inhalation is of metallic and mineral dusts. The statistics available suggest the necessity of a thorough and qualified investigation to determine with more accuracy the facts regarding the mortality of cotton workers.

TEXTILE SPINNERS.

Spinning, in cotton and woolen manufacture, is peculiarly an employment of women and children, who constitute the large majority of persons employed in American and foreign mills. It is true, as pointed out in the census report on cotton manufacture, that in proportion as the speed of machinery increases women and children are displaced by men,(a) but even under modern conditions out of 55,488 frame spinners employed in the manufacture of cotton textiles only 10,709 were men, or 19.3 per cent. Of the remainder, 25,701 were women and 19,078 children. Mule spinners are almost invariably men, but the number of mule spinners in the cotton industry is not large, and in 1905 was only 4,866, of whom 3,691 were employed in the New England States.(b) In spinning the amount of visible dust is not considerable, but large quantities of fly or flue are produced during the spinning, twisting, and drawing operations, which rapidly accumulate on and about the machines, requiring constant cleaning and dust removal, for which practically no effective provision is made in most of the American mills at the present time. The employment has the serious disadvantage of a comparatively high and moist temperature, which, according to Arlidge, during the summer months induces "exhaustion, sweating, and debility; results the more felt because spinning entails nearly constant standing, or slight movements to and fro to follow the 'mule frames.'" Arlidge observed, further, that "what renders the spinning rooms more insanitary than they would be otherwise, considering their general spaciousness, is that the temperature is maintained night and day, and that all inlets for air are kept carefully closed. In consequence, there is not the necessary renewal of air for healthy breathing. Moreover, in such close rooms the operatives acquire a particular sensitiveness to currents of air and to change of temperature, and are themselves opposed to most attempts at ventilation. Happily, these remarks are not so generally applicable as they were formerly, for the better recognition of what constitutes ventilation, together with the skill of engineers, has worked a great reform in the sanitary state of spinning rooms." The mortality from consumption among spinners is known to be high, both among men and women, and, no doubt, in a large measure this is the direct result of the employment. The degree of consumption frequency among spinners, however, is possible of a material reduction under satisfactory conditions of light, temperature, and ventilation. Modern American cotton mills, especially in the South, are in many respects more hygienic than the old type granite structures typical of New England. Compared with certain foreign countries, the mortality of cotton spinners, at least, would appear to be somewhat lower in the United States, due, no doubt, largely to the more recent development of the industry and the generally more satisfactory conditions of labor and life in this country.

(a) Census of Manufactures, 1905, Part III, p. 30.

(b) Census of Manufactures, 1905, Part III, p. 50.

The only really trustworthy general mortality statistics of spinners are the returns for Blackburn, England, prepared annually under the direction of Dr. Alfred Greenwood, the medical officer of health. An admirable analysis of these returns by Mr. F. S. Crum was published in the New York Medical Record for August 11, 1906, and from the tables there presented are extracted the following comparative death rates of spinners and weavers, including separately the rates for consumption and for other respiratory diseases:

MORTALITY OF **SPINNERS AND WEAVERS** IN BLACKBURN, ENGLAND, 1889 TO 1905.

Age at death.	Death rate per 1,000 from all causes of—		Death rate per 1,000 from consumption among—		Death rate per 1,000 from other diseases of the respiratory system of—	
	Spinners.	Weavers.	Spinners.	Weavers.	Spinners.	Weavers.
15 to 24 years	5.3	3.7	1.3	1.1	0.8	0.4
25 to 34 years	7.7	4.8	2.5	2.4	1.9	.7
35 to 44 years	10.3	9.1	2.8	1.9	2.2	1.8
45 to 54 years	25.7	14.9	2.4	1.8	7.9	4.8
55 to 64 years	43.7	44.7	.8	2.8	17.8	15.1
65 years or over	177.7	139.5	1.8	.9	48.8	35.6

In the State of Rhode Island, during the five years ending with 1906, there were recorded only 71 deaths of male spinners, and of this number 18, or 25.4 per cent, were from consumption, and 5, or 7 per cent, were from other respiratory diseases. It is quite probable, however, that the actual mortality was greater than the recorded on account of the difficulty in securing, without special inquiry, accurate information as to decedents' exact occupation at the time of death.

The recorded industrial insurance mortality statistics of spinners include 189 deaths from all causes, of which 56, or 29.6 per cent, were from consumption. Of the mortality of spinners from respiratory diseases other than consumption, 17 were from pneumonia, 6 from asthma and bronchitis, and 5 from less frequent respiratory diseases. If the deaths from consumption and from other respiratory diseases are combined, 44.4 per cent of the mortality of spinners was from diseases of the lungs and air passages. Spinners, as grouped for the purpose of this investigation, include spinners of textiles generally, but chiefly those in the cotton industry. Because of the fact that the large majority of spinners are women, the mortality experience with this class of labor is comparatively small. The excess in the consumption mortality of spinners is more clearly brought out in the tabular presentation of the proportionate mortality from this disease by divisional periods of life. Although the consumption mortality was excessive at all ages under 55, the excess was most pronounced at ages 25 to 34, when out of every 100 deaths from all causes 50 were from consumption, against a normal expected proportion of 31.3. The analysis of the consumption mortality of spinners in detail is set forth in the table below:

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG **SPINNERS**, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for spinners from experience of an industrial insurance company; figures for males in registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of spinners, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Spinners.	Males in registration area, 1900 to 1906.
15 to 24 years	28	13	46.4	27.8
25 to 34 years	38	19	50.0	31.3
35 to 44 years	36	16	44.4	23.6
45 to 54 years	27	7	25.9	15.0
55 to 64 years	37	1	2.7	8.1
65 years or over	23	....	....	2.7
Total	189	56	29.6	14.8

The preceding statistical data, including the industrial insurance mortality experience, confirm the conclusion that the mortality of spinners from consumption is considerably above the average throughout practically the entire active working period of life, but in particular between the ages of 15 and 54, inclusive.

TEXTILE WEAVERS.

Weaving is a more arduous occupation than spinning, but apparently the health conditions affecting this employment are more favorable than the corresponding conditions in the spinning rooms. Spinning attracts the less physically strong or those who because of their frail physique would be predisposed to consumption. This, in part, no doubt, accounts for the difference in the mortality rates of the two employments. The census of 1905 returned the number of weavers of cotton goods in the United States as 98,807, but of these 50,559 were women and young persons.([a]) Arlidge describes the conditions in weaving rooms, with special reference to health-injurious circumstances, in part, as follows:

> Weaving sheds are of vast dimensions, and, in some instances, hold 1,000 looms. The noise in the winding and spinning rooms is very great, but in the huge weaving sheds it is almost deafening. At the same time, the places are excessively hot; and the air is charged with moisture, and, when there is heavy sizing, with dust of china clay, the same material as used in making pottery. Added to these insanitary circumstances are bodily exhalations of the workers—breath and perspiration. The heat and moisture are necessary to prevent the undue breakage of the yarn in the act of weaving, and the more so where the yarn is of inferior quality and is heavily sized, to make it marketable.

Conditions in American weaving rooms are probably somewhat better than in England, especially on account of the fact that the sizing used in the preparation of the warp is, as a rule, of common starch, sago, or some similar vegetable compound, instead of china clay dust, which is in common use in English factories. The weaving rooms in American mills are usually high-studded but rarely as well ventilated as would be necessary to secure the best conditions favorable to health and life. Effective artificial ventilation is the exception rather than the rule. The conditions as to temperature and artificial humidity are probably less favorable in weaving rooms than in spinning rooms, but in the latter a considerable amount of fly or dust is generated during the spinning processes. English mortality statistics of weavers indicate a lesser liability to consumption and other respiratory diseases among this class than among spinners, but it must always be taken into account that such statistics are likely to err seriously with advancing age when it becomes very difficult to account for those who have retired from the textile industry to follow other and less arduous employments. It is open to question whether the recent English attempt to account for the entire mortality of all the occupied and retired in certain specified trades really has been a success and warrants the conclusions arrived at.

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[a] Census of Manufactures, 1905, Part III, p. 50.

In the analysis by Mr. F. S. Crum of the mortality of spinners and weavers a comparison is made of the death rate of English weavers with the general average death rate in the registration area of the United States, which is reproduced here to emphasize how even an admittedly imperfect registration of the mortality of this trade indicates a decidedly high death rate among this class:

PROPORTIONATE MORTALITY OF **WEAVERS** FROM CONSUMPTION AND OTHER RESPIRATORY DISEASES, BLACKBURN, ENGLAND, 1899 TO 1905.

Age at death.	Per cent of deaths due to consumption among weavers in—		Per cent of deaths due to other respiratory diseases among weavers in—	
	Blackburn, England.	United States registration area, 1900.	Blackburn, England.	United States registration area, 1900.
15 to 24 years	28.9	30.9	10.8	9.5
25 to 34 years	50.6	32.4	14.0	10.4
35 to 44 years	20.8	22.6	19.3	12.2
45 to 54 years	12.1	13.3	32.0	13.4
55 to 64 years	6.4	7.6	33.7	14.6
65 years or over	.6	2.9	25.5	14.7

The Rhode Island statistics of mortality by occupation only record the deaths of weavers, beginning with the year 1901. During the period 1901 to 1906 the recorded mortality of weavers from all causes was 259, and of this number 67, or 25.9 per cent, were from consumption and 30, or 11.6 per cent, from other respiratory diseases. Of the total mortality 97, or 37.5 per cent, were from diseases of the lungs and air passages.

The recorded industrial insurance mortality statistics of weavers include 915 deaths from all causes, of which 254, or 27.8 per cent, were from consumption. Of the mortality of weavers from respiratory diseases other than consumption 78 were from pneumonia, 10 from asthma, 18 from bronchitis, and 13 from less frequent respiratory diseases. If the deaths from consumption and from other respiratory diseases are combined, 40.8 per cent of the mortality of weavers was from diseases of the lungs and air passages. The number of deaths of weavers under consideration is exceptionally large and strictly representative of this important occupation. It is difficult, however, to determine the kind of dust exposure to which this class of labor was most subject, since the term is a general one, including employments in every branch of textile manufacture. The excess in the consumption mortality of weavers is more clearly brought out in the tabular presentation of the proportionate mortality from this disease by divisional periods of life. While the consumption mortality was excessive at all ages, the excess was most pronounced at ages 25 to 34, when out of every 100 deaths from all causes 53.4 were from consumption, against a normal expected proportion of 31.3. If the proportionate mortality of weavers is compared with the corresponding mortality of spinners, it appears that while for spinners the proportion was 46.4 per cent at ages 15 to 24 it was 39.8 per cent for weavers; at ages 25 to 34 the proportion was 50.0 per cent for spinners, against 53.4 per cent for weavers; at ages 35 to 44 the proportion was 44.4 per cent for spinners, against 38.1 per cent for weavers, and at ages 45 to 54 the proportion was 25.9 per cent for spinners, against 25.7 per cent for weavers. At ages 55 or over the numbers for spinners are too small for an entirely safe conclusion. The comparison would warrant the opinion that the occupation of spinners is somewhat more exposed to health-injurious conditions, resulting in a somewhat higher proportionate consumption mortality from this employment. The analysis of the consumption mortality of weavers in detail is set forth in the table below:

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG **WEAVERS**, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for weavers from experience of an industrial insurance company; figures for males in registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of weavers, 1897 to 1906 due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Weavers.	Males in registration area, 1900 to 1906.
15 to 24 years	108	43	39.8	27.8
25 to 34 years	174	93	53.4	31.3
35 to 44 years	155	59	38.1	23.6
45 to 54 years	144	37	25.7	15.0
55 to 64 years	137	15	10.9	8.1
65 years or over	197	7	3.6	2.7
Total	915	254	27.8	14.8

The preceding observations and mortality statistics, including the insurance experience, confirm the conclusion that the mortality of weavers from consumption is excessive at all ages, but in particular at ages 15 to 64, or throughout the entire period of the active working lifetime of persons employed in this occupation.

MANUFACTURE OF HOSIERY AND KNIT GOODS.

The manufacture of hosiery and knit goods has within recent years attained to very large proportions in the United States, giving employment to 103,715 wage-earners in 1905, of whom 66.4 per cent were women and 9.3 per cent children and young persons under 16 years of age. The rapid growth of this industry is illustrated by the fact that during the five years ending with 1905 the number of wage-earners increased 24.4 per cent, while the value of the product increased 43 per cent. The number of knitting machines during the same period increased from 69,047 in 1900 to 88,374 in 1905. ([a]) About one-third of these are automatic circular hosiery machines, but the amount of dust generated during knitting processes is practically the same, irrespective of the kind of machinery in use. The material used in knitting and hosiery manufacture is chiefly cotton and woolen and worsted yarn, but considerable quantities of shoddy, jute, hemp, silk, and mohair are also used in an endless variety of combinations, which vary widely from year to year, according to the demands of the trade. It has seemed best, however, for the present purpose to include the manufacture of hosiery and knitted goods under the employments exposing chiefly to the risk of vegetable dust inhalation, since over one-half of the material used is cotton or some other vegetable fiber. The health conditions in knitting and hosiery mills conform quite closely to those of cotton and woolen spinning and weaving rooms. The health-injurious effects of the industry are probably most pronounced in the spinning, weaving, knitting, finishing, calendering, and drying rooms, but no qualified investigation has been made to warrant final conclusions.

There are no official vital statistics of hosiery and knit goods manufacture for the United States, and thus far no analysis has been made of the mortality of this class in the cities and towns where the industry is concentrated and where large numbers are employed. The Rhode Island statistics for knitters are not of determining value, since only 8 deaths of male knitters have been recorded during the ten years ending with 1906, but of this small number 5, or 62.5 per cent, were deaths from consumption.

The mortality of hosiery workers in England and Wales is referred to in the Supplement to the Sixty-fifth Annual Report of the Registrar-General, as follows:

> The death rates of hosiery workers exceed the standard for occupied and retired males at ages 20 to 25 and 55 years and upward, while at other ages the rates are below the standard. In the main working period of life the comparative mortality figure is 921, or 8 per cent below the standard. The mortality from phthisis exceeds the average

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[a] Census of Manufactures, 1905, Part III, p. 68.

by one-fifth part, and there is also a slight excess from cancer, circulatory diseases, and suicide, whilst from every other cause the mortality is below the standard; the mortality from influenza, from alcoholism and liver disease, from Bright's disease, and from accident, shows a marked defect as compared with the average.([a])

The English occupation mortality statistics for persons employed in hosiery manufacture are of considerable value, since they include 881 deaths from all causes occurring during the three-year period ending with 1902. Of this number of deaths 97, or 11 per cent, were from consumption, and 161 deaths, or 18.3 per cent, from other respiratory diseases, which combined give 29.3 per cent of the mortality from diseases of the lungs and air passages. In the table which follows a comparison is made of the mortality from all causes among men in this group with that of occupied males generally, and the result is suggestive of conditions in this trade decidedly unfavorable to health and life at ages 55 or over:

MORTALITY FROM ALL CAUSES AMONG MALES EMPLOYED IN **HOSIERY MANUFACTURE**, COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 for all occupied males.	Death rate for males in hosiery manufacture.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	2.44	1.00	− 1.44	41
20 to 24 years	4.41	5.75	+ 1.34	130
25 to 34 years	6.01	5.39	− .62	90
35 to 44 years	10.22	6.71	− 3.51	66
45 to 54 years	17.73	16.10	− 1.63	91
55 to 64 years	31.01	35.11	+ 4.10	113
65 years or over	88.39	132.12	+43.73	149

The death rates of men employed in hosiery manufacture are below the general average at all ages under 55 except at ages 20 to 24, when, however, small numbers are in part responsible for a possibly accidental fluctuation in the death rate.

In the table which follows the mortality from consumption and from respiratory diseases other than consumption among men employed in hosiery manufacture is compared with the normal mortality of occupied males from these diseases by divisional periods of life. The comparison shows that the mortality from consumption was above the average at all ages under 65 except at 35 to 44. The returns are not entirely conclusive and are possibly impaired by the more or less fluctuating character of the population and the tendency to leave the manufacture of hosiery for other branches of the textile industry. The mortality from other respiratory diseases was below that of all occupied males at all ages under 65.

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[a] Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales, p. xc.

MORTALITY FROM CONSUMPTION AND FROM OTHER DISEASES OF THE RESPIRATORY SYSTEM AMONG MALES EMPLOYED IN **HOSIERY MANUFACTURE,** COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Mortality from consumption.				Mortality from other diseases of the respiratory system.			
	Death rate per 1,000 for all occupied males.	Death rate for male hosiery workers.			Death rate per 1,000 for all occupied males.	Death rate for male hosiery workers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years.....	0.54	0.60	+0.06	111	0.24	0.20	−0.04	83
20 to 24 years.....	1.55	2.35	+ .80	152	.48	.26	− .22	54
25 to 34 years.....	2.03	2.46	+ .43	121	.77	.70	− .07	91
35 to 44 years.....	2.74	2.48	− .26	91	1.66	.75	− .91	45
45 to 54 years.....	3.04	4.23	+1.19	139	3.32	2.93	− .39	88
55 to 64 years.....	2.16	3.47	+1.31	161	6.54	6.01	− .53	92
65 years or over..	1.11	.79	− .32	71	17.77	27.06	+9.29	152

The recorded industrial insurance mortality statistics of hosiery and knitting mill employees include only 65 deaths from all causes, of which 24, or 36.9 per cent, were deaths from consumption. The excess in the consumption mortality of hosiery and knitting mill employees is clearly brought out in the tabular presentation of the proportionate mortality from this disease by divisional periods of life.

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG **HOSIERY AND KNITTING MILL EMPLOYEES,** 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for hosiery and knitting mill employees from experience of an industrial insurance company; figures for males in the registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of hosiery and knitting mill employees, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Hosiery and knitting mill employees.	Males in registration area, 1900 to 1906.
15 to 24 years..........	23	5	21.7	27.8
25 to 34 years..........	22	15	68.2	31.3
35 to 44 years..........	7	2	28.6	23.6
45 to 54 years..........	9	2	22.2	15.0
55 to 64 years..........	3	....	....	8.1
65 years or over..........	1	....	....	2.7
Total..........	65	24	36.9	14.8

It is found, in summarizing these observations and statistical data, that they do not warrant final conclusions but suggest the necessity of a qualified and extended investigation to determine with accuracy the facts regarding the mortality of this class of labor.

LACE MANUFACTURE.

Lace making in the United States has not as yet attained to considerable proportions, but the perfection of machinery for lace making gives promise of a considerable development of this industry in the United States in the future. The subject has attracted the attention of the Bureau of Manufactures, and a very interesting descriptive report on machine-made lace in Europe was recently published by the Department of Commerce and Labor. According to this report lace making by machinery is an extremely complicated process, with resulting labor conditions quite closely resembling those of hosiery and knit-goods manufacture. No very satisfactory account of the conditions of labor in this industry has been published, with special reference to the different employments, except lace dressing, which is held to be accompanied by serious health-injurious consequences, but chiefly on account of the high temperature under which this process is carried on. In a special report upon lace dressing, by the medical officer of health of the city of Nottingham, England, this process in its relation to health is in part described as follows:

The lace, after having been bleached, and, in some cases, dyed, and then dipped in starch solution, is taken in rough and wet condition to the dressing (or drying) rooms (usually over 100 yards long by 15 to 20 yards wide and 9 to 10 feet high) and there stretched upon horizontal frames to dry. In the case of some fine silk nets, the unstarched fabric is placed upon the drying and stretching frames, and the dressing applied to the stretched material on the frames. The dressing rooms are heated by steam or hot-water pipes, and their temperature usually ranges, in this country, from 75° to 100° F. It is made to vary to suit the requirements of different materials and according to the condition of the external air. In very hot and dry weather, all artificial heat is occasionally dispensed with for cotton goods; but for silk goods, which are reputed to require specially quick drying, artificial heat is always employed, and the temperature of some silk-lace dressing rooms in Lyon (France) is said often to be as high as between 130° and 140° F. The drying process is assisted by large revolving fans placed directly over the drying material.

The Stenter dressing or drying machine calls for special mention, as its use frequently modifies the distribution of hot air in the rooms where it is employed. In this machine, which is used principally for lace curtains, the fabric is carried by an endless chain into an atmosphere heated by multitubular boilers (the air being driven through the steam-heated boiler tubes), and the whole mechanism, with its contained lace material, is usually boxed in with wooden casing furnished with ventilating openings. In rooms where this machine is in use, the temperature seldom rises above 80° F., except in the immediate neighborhood of these openings and at the feeding end of the machine.

The investigation at Nottingham was a thoroughly qualified inquiry, including a careful consideration of the available vital statistics referring not only to those who had been continuously employed in lace dressing, but also to those who had been casually employed; the number of the latter was found to be considerable. Many of the lace factory employees were interviewed and examined, but the opinion was practically unanimous that lace dressing, even if followed for many years, is not dangerous to health. Many of the employees were found to suffer a good deal from common colds, but such colds did not appear to be of greater frequency than among factory workers in general. The investigation did not disclose any special tendency to phthisis or to other lung diseases among the women, who alone work continuously in the dressing room, and this in the opinion of Dr. Philip Boobbyer, the author of the report, was more remarkable, since the majority were of a very poor class, living in poor houses and poor neighborhoods, and many no doubt led irregular and intemperate lives. The result of the investigation was summed up in the statement that—

> Probably the strongest argument in support of the contention that lace dressing, as now carried on in Nottingham, is a healthy occupation, is to be found in the fact that large numbers of women have worked at it for very long terms of years continuously, have had good health while doing so, and have lived to advanced old age, either at work or in retirement. I have alluded elsewhere to the question which naturally arises, as to how far the case of these women is to be regarded as an illustration of the survival of the fittest, but up to this point have answered it only by general statements.
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> Although, as I have said, there are a good many people who have left this work for various causes after having tried it for a time, there are, on the other hand, large groups of those who have taken it up and adhered to it continuously during the whole period of their working lives, and the duration of these has certainly, in the majority of cases, been remarkably long. The only possible inference to be drawn from facts and figures like these is that the work people have established an absolute tolerance of the abnormal atmospheric conditions which exist in the lace-dressing rooms, and that life, and vigorous life, can be maintained to old age under these conditions.

Since lace dressing as carried on in England is practically a woman's employment, males employed in the lace industry generally did not come within the scope of the inquiry. Dr. Boobbyer, however, pointed out that the death rate from phthisis among the males was found to be high in contrast to the low death rate from phthisis among the females, but owing to the smallness of the number of men employed, and the continual fluctuation in this number, the expression of their phthisis mortality by means of a definite rate would, because of this fact, be seriously misleading.

Lace making in its relation to health was considered at some length by Arlidge, who first calls attention to the gradual changes from the rapid displacement of handmade lace by machine-made lace, and the decay of the industry in Nottingham, which, in his opinion, from a purely hygienic point of view was not an unmixed evil on account of the high ratio of phthisis and scrofula observed by him to prevail among those who followed this occupation. He refers to the occupation divisions in machine-made lace, chiefly lace making proper, finishing, and mending, the last named process being subdivided into dressing, gauffering, bleaching, and dyeing. The process of gauffering is, in his opinion, a particularly injurious one to health, chiefly on account of the fact that the machines are heated by gas. He states that—

> It is a division of the occupation which is regarded on all hands as very unhealthy, chiefly on account of the very great heat connected with it and, in less measure, of a sickly smell evolved. The "finishing" of cotton lace entails a higher temperature than that of silk lace. The same fact applies when "Paris" dressing is done. The presence of a large surface of moist tissue and the elevation of temperature necessarily imply a more or less humid atmosphere and free perspiration. Fortunately the admission of fresh air is permissible at times from open windows. For the most part finishing rooms are heated by hot water or steam pipes, though in some factories open fires are found in the making-up departments; the air is dry, and the making-up machines, heated by gas or by steam pipes, render it very hot, especially when several of them are situated in the same apartment.

A summary of these conclusions of qualified observers seems to warrant the opinion that dust, in relation to lace manufacture, is reduced to a minimum and apparently is not of a serious consequence to the employees. This opinion is confirmed by English vital statistics, which indicate that the death rates from phthisis are at least not above the average, and at some divisional periods of life they are decidedly below the average of consumption frequency in other branches of textile manufacture.

The most recent English mortality statistics of lace manufacture are for the three years ending with 1902, referred to in the Supplement to the Sixty-fifth Annual Report of the Registrar-General in part as follows:

> The number of male lace workers is comparatively small, and it is found that as compared with the standard for all occupied and retired males, the death rates at the several groups of ages fluctuate considerably, being below that standard at ages 20 to 25 and 35 to 55,

and above it at all other ages. In the main working time of life the comparative mortality figure is 950, or 5 per cent below the standard. Lace workers appear to suffer little from influenza and respiratory diseases, and only half the ordinary fatality from accident. They show, however, a marked excess in the mortality from cancer, and the mortality from alcoholism and liver disease as well as from phthisis, from nervous and circulatory diseases and from suicide also exceeds the standard.([a])

The recent English mortality statistics for lace workers are not quite conclusive and do not warrant an entirely definite opinion as to the health injurious effects of this employment. In the table which follows, a comparison is made of the mortality from all causes among men in this group with that of occupied males generally, and the comparison shows that the general death rate of lace workers was above the average at ages 15 to 19, 25 to 34, and 55 to 64. Since the number of men employed in this industry is comparatively small the statistical data do not warrant final conclusions.

MORTALITY FROM ALL CAUSES OF MALE **LACE WORKERS**, COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 for all occupied males.	Death rate for male lace workers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	2.44	2.58	+0.14	106
20 to 24 years	4.41	2.69	−1.72	61
25 to 34 years	6.01	6.71	+ .70	112
35 to 44 years	10.22	8.38	−1.84	82
45 to 54 years	17.73	11.68	−6.05	66
55 to 64 years	31.01	32.56	+1.55	105
65 years or over	88.39	87.56	− .83	99

The preceding table is self-explanatory and requires no further comment. A more extended comparison is made in the next table, in which the mortality of lace workers from consumption is compared with the normal mortality of occupied males generally, by divisional periods of life. The comparison shows that the mortality from consumption was excessive at the same age periods at which the general death rate was above the normal, but the excess was not very marked and does not warrant a decidedly unfavorable conclusion regarding the possible health-injurious effects of this industry.

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[a] Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales, p. lxxxviii.

MORTALITY FROM CONSUMPTION AMONG MALE **LACE WORKERS**, COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Mortality from consumption.			
	Death rate per 1,000 for all occupied males.	Death rate for male lace workers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	0.54	1.13	+0.59	209
20 to 24 years	1.55	1.12	− .43	72
25 to 34 years	2.03	2.84	+ .81	140
35 to 44 years	2.74	2.39	− .35	87
45 to 54 years	3.04	2.57	− .47	85
55 to 64 years	2.16	2.22	+ .06	103
65 years or over	1.11	.74	− .37	67

For a final and entirely conclusive opinion additional information is required, but at present no trustworthy statistical data are available for the United States.

FLAX AND LINEN MANUFACTURE.

The manufacture of flax, hemp, and jute products in the United States is only gradually assuming large proportions, considering the enormous demand for the finished product. The United States Census of Manufactures of 1905 enumerates 24,508 wage-earners employed in this industry, but of this number only 12,343 were adult males, while 10,072 were women and 2,093 children under 16 years of age. As pointed out in a report on this industry by Mr. Edward Stanwood, expert special agent of the census, "Hardly any general class of manufactures is more difficult of treatment, either as a whole or in detail, than that of flax, hemp, and jute. The materials are closely allied, in that they are all vegetable fibers, and in that two and sometimes all three are used in the same establishment and not infrequently introduced into the same fabric. Yet the products are so diverse, ranging from gunny bags and ships' hawsers to fine toweling and sewing thread, that the propriety of embracing all these varied industries in a single class, which seems so evident when materials only are considered, practically disappears." "A list of the products includes yarn and twine made from each one of the three fibers; linen thread; woven fabrics, partly or wholly of linen; rope and binder twine of manila or of sisal, or of the two mixed; gunny bagging, jute burlaps, carpets, rugs, and other minor products."([a])

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[a] Census of Manufactures, 1905, Part III, p. 187.

Of these products the manufacture of cordage and twine and of jute and jute goods will be separately considered, so that it is only necessary here to refer briefly to linen manufacturers and important processes necessary for the manipulation of flax. The linen manufacture is a very limited one in the United States, since the census only enumerates 15 establishments, giving employment to 3,811 wage-earners, and of this number only 1,260, or 33.1 per cent, were adult males. As stated in the census report, "Relatively little attention is given to the preparation of the flax fiber for manufacture, and that which is prepared is adapted only to the coarser processes. Imported material is employed almost exclusively in the spinning of yarns and the weaving of fabrics in the United States. There has never been a successful attempt in this country to produce fine goods at a profit."([a])

The material used in linen and thread manufacture is the fibrous portion of the flax plant, which, in this country, for reasons which do not require to be discussed, is chiefly cultivated for the seed. The preliminary processes are pulling, threshing, and retting, necessary to prepare the flax straw for the breaking and scutching processes. The scutching process, whether by hand or machinery, is an exceedingly dusty occupation, subject, however, to material modification by effective ventilation stacks which carry off much dust which would otherwise pollute the atmosphere of the room. With the subsequent processes begins the linen manufacture proper, and the first operation is called "heckling," which also may be performed either by hand or machinery. Heckling is also an exceedingly dusty process, and the conditions are not much better in the subsequent operation of sorting. Spreading and drawing are intermediary processes, previous to the sliver being taken to the roving frame, after which the fiber is ready for spinning, which for practical purposes conforms to the mule spinning operations in cotton mills, although the amount of dust generated during this process is probably greater. Spinning is followed by reeling, drying, warping, sizing, beaming, and drawing in, previous to the final process of weaving, all of which are operations practically indentical with the corresponding process in cotton manufacture.

Referring to the health-injurious circumstances of particular employments in flax and linen manufacture, Bevan, in his treatise on Industrial Classes and Industrial Statistics of the United Kingdom, gives a very vivid descriptive account, which is reproduced in part as follows:

Heckling, which is performed by girls and boys, is always a very dusty operation, and requires a good deal of continuous labor. In the report of Bridges and Holmes, it is said that "the ill effects of the heckling efforts upon the boys (technically called machine boys) engaged in it are shown in spasmodic attacks of cough, during which the boy generally holds on to the machine to assist the efforts of coughing; an effort so familiar to workers that a boy who is observed doing so is said to be 'poucey,' from the 'pouce' or dust by which the cough is provoked. This dust is both fibrous and granular, but the latter very largely preponderates. It is for the most part a fine, soft, and palpable powder, proceeding evidently in great part from the putrefying process to which the flax plant has been subjected. Mixed with these organic particles there is, doubtless, a considerable portion of pulverized mud." This peculiar affection is spoken of as being very common in the Belfast mills. ([a])

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[a] Census Manufactures, 1905, Part III, p. 191.

In the preparation of the flax a separation is made of the short and coarse fiber, which is known as tow and which contains the largest quantity of dust, dirt, and woody fiber. Bevan states that after being sorted tow "is carded just like cotton, except that it is on a rougher scale, and makes infinitely more dust. The tow-carding room is the worst place in the mill, and the clothes of the workers are generally loaded with the dust which floats thickly through the room, notwithstanding the adoption of powerful exhaust fans in the roof or the external walls. What with the dust and the damp from the steam jets, it is the most unhealthy employment in flax spinning; but, though efforts have been repeatedly made to induce the women to wear respirators, it has been without success."

The dusty condition of the workrooms in tow manufacture is not, however, the only objectionable feature in this branch of the industry, for in the practice of wet spinning the rove of the tow is drawn through a trough of warm water, which results not only in an exceedingly warm atmosphere, but also a very damp one, owing to the spray which is sent off from the spindles. Unless atmospheric conditions are regulated with great care the health of employees is seriously affected, particularly in the case of women. The following quotation gives the opinion of Bevan regarding the injurious conditions in the manufacture of flax products:

> The flax trade is the most unhealthy, and no person should work in it who has any pulmonary weakness. Doctor Purdon says, in his evidence, that "nearly three-fifths of those that die annually in this trade are taken off by diseases of the respiratory organs. In the preparing rooms, the death rate from chest affections is exceedingly high, being 31 per 1,000, and amongst the hecklers the deaths annually amount to 11.1 per 1,000, amongst the weavers to 9 per 1,000. In wet spinning the children often get their clothes wet with the spray that comes off from the spindles, and on coming out of the hot room with their clothes damp in the evening, it brings on bronchial affec-

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[a] In this connection reference may be made to the recently published report of the Belfast Health Commission to the Local Government Board of Ireland, p. 95. Dublin, 1908.

tions." The same observer states that the average life of flax carders is 45.7 years, and the average length of time employed 16.8 years; of preparers, average of employment, 28.7; of dressers, average of employment, 16.6. From an analysis of the fiber it seems that 100 parts of flax contain 13 of silica. From the preceding facts it would appear that the Belfast mills are not in that state of sanitary arrangement in which they ought to be.(a)

These statistical references must be used with caution, since they refer to an earlier period, when conditions were less satisfactory than they are at the present time.

The unfavorable conclusions of Bevan regarding the health-injurious conditions in flax and linen manufacture are fully sustained by numerous investigations which have been made during the last fifty years. The earliest qualified inquiry was made by Doctor Greenhow, and was included in the privy council's medical report for 1860. Doctor Greenhow's report is of special value in that attention is called to the differences in the health-injurious quality of different kinds of flax dust, and from his observations the following extract is made:

> Of the several processes carried on in flax mills, hackling, carding, and line preparing are more or less dusty, so that the atmosphere of the rooms in which they are going on is loaded with dust in proportion to the quality of the flax that is being manufactured and the means employed to prevent the dispersion of the dust into the air and its inhalation by the operatives. Several varieties of flax, named from the places whence they come, are manufactured in this country. The most common are the Dutch, Baltic, Irish, French, and Flemish, which yield dust in the process of manufacture in the order in which they have been named, the Dutch being the most, the Flemish the least, dusty. Flax is also imported from America and India, both of which varieties are said to be very dusty. There are, moreover, several varieties of each kind of flax which differ materially from one another; and it is said that, independently of other circumstances, the mode of preparing the flax causes a difference in the dustiness of the article when it comes to be manufactured, that which has been prepared by exposure to rain upon the grass being less dusty than such as has been steeped in water. The manufacture of the refuse from the hackle, called tow, which is spun into coarser material, is likewise attended by much dust. The danger to health will differ in different manufactories, according as the least or the most dusty kind of flax is manufactured. Several operatives asserted that they had not suffered sensibly in health from their occupation until they worked in Dutch flax, when the inhaling of the dust soon caused bronchial irritation. Of the several above-named processes, hand hackling is the most pernicious; this process has now been partially superseded by machine hackling, which, though still often injurious to the health of the operatives, is decidedly less so than the former. There is likewise a considerable quantity of dust

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[a] Bevan's The Industrial Classes and Industrial Statistics, Volume on Textiles and Clothing, p. 44.

given off in the processes of carding and line preparing, from which the operatives suffer in proportion to its amount.

After emphasizing the great value of an effective system of ventilation, Greenhow includes a discussion of the pathology of dust inhalation in flax and linen factories, which is one of the most valuable references on the subject, and which, in part, reads as follows:

> The effects of exposure to the dust of flax are manifested upon the mucous membranes. The stomach is very apt to become deranged by the dust swallowed, and hence the flax operatives, more particularly the hacklers, often suffer from dyspepsia, and are sallow and look sickly; the eyes often become sore, the margins of the eyelids being swollen and inflamed, and the sight is said occasionally to become impaired. But the most serious effect is produced on the mucous membrane of the air passages; oppression of the chest, followed by dyspnœa, cough, and eventually by expectoration, are ordinary results of inhaling air charged with the dust of flax. Epistaxis is an occasional, and hæmoptysis a very frequent consequence of the same cause. It is remarkable that dyspnœa, sometimes of an asthmatic character, often long precedes the accession of cough and expectoration, or perhaps, more properly speaking, the cough and expectoration are in the beginning too slight to attract the notice of the sufferer, whilst the dyspnœa reminds him of its presence whenever he attempts brisk locomotion. As has already been said, many of the flax operatives forsake the occupation at an early age on account of the injurious influence it exercises over the health; but though this is true, the injury to health is commonly very gradual, and constant discomfort and serious disease only become established toward middle life, men employed in any dusty department of the manufacture rarely attaining the age of 45 or 50 years without suffering more or less severely from bronchial disease.

Efforts to induce workmen and women to use respirators had been a failure, although out of 107 persons medically examined 79 were suffering from some degree of bronchial irritation, ascribed to the unhealthy nature of the employment. While some had attained to quite advanced age, Greenhow points out that—

> Notwithstanding that men at ages so advanced as 60 years and upward are sometimes found working as hand hacklers, the attainment of this age must, from the all but universal statements of both employers and operatives, be deemed exceptional. It was stated by manufacturers, foremen, overlookers, and the operatives themselves that working in the more dusty departments of the manufactory rarely fails to make itself felt toward middle life, few persons being able to work in an atmosphere loaded with the dusty particles for twenty years continuously without sustaining serious injury to health. The health of the women employed in the line-preparing room of another factory was inquired into in the manner adopted with regard to the hacklers, already mentioned. It is always difficult to obtain direct evidence from female operatives; but the inquiry showed that all those who had worked for a considerable length of time in this branch of manufacture were asthmatical, and that several of them had suffered from haemoptysis. The operatives employed in the

carding rooms, unless the machines be properly protected to prevent the dispersion of the dust, frequently labor under habitual dyspnœa, cough, and expectoration; and it is especially in the carding rooms that the operatives are accustomed to tie up their mouths to prevent them inhaling the dust. The effect on a healthy stranger of entering these rooms is most unpleasant; the dust floating in the atmosphere irritates the nasal and bronchial passages, producing sneezing and a sense of oppression in the chest, which do not cease until some time after the visitor has left the apartment. The manager of a large factory asserted that remaining for any continuance in one of the carding rooms invariably produced in him, for a time, all the symptoms and sensations of catarrh. ([a])

While the observations of Greenhow pertain to an early period, they apply to present-day conditions, although some improvement has been brought about in the meantime as the result of rational factory legislation. The continuous observation of actual conditions and the frequent qualified inspections made by medical inspectors of flax and linen factories in the United Kingdom have warranted from time to time modifications in the rules governing the conditions of employment, and these were finally amended in 1906 with special reference to processes of spinning and weaving flax and tow and the processes incidental thereto. Among other provisions, it is required that "in every room in which roughing, sorting, or hand hackling is carried on, and in every room in which machine hackling, carding, or preparing is carried on, and in which dust is generated and inhaled in a quantity calculated to cause injury to the health of the employees, a sufficient exhaust should be provided to insure that the dust is drawn away from the workmen at or as near as possible to the point at which it is generated." These regulations governing flax and linen manufacture in the United Kingdom at the present time were carried into effect upon the results of a special investigation made by Hamilton P. Smith, one of His Majesty's superintending inspectors of factories, of the conditions of work in flax and linen mills as affecting the health of operatives employed therein, and from which, in part, the following is quoted, with special reference to the dust problem.

In roughing, sorting, and machine and hand hackling rooms, and in all preparing rooms, the source of danger to health lies chiefly in the fact that large quantities of dust of an injurious nature are generated in the processes of manufacture, and accumulated testimony shows that the workers suffer in health. The raw material after leaving the scutch mill is subjected to the process of combing, laying parallel, and sorting the fibres of flax. This is done partly by hand and partly by machinery. Taking a rough handful or strick of rough flax, the operative by a swinging motion dashes the fibers onto the vertical needles forming the rougher or hackle. The fiber is drawn through these teeth, separating inferior and short fibers from the better ones and leaving "tow" as the residual. The subsequent processes of hand hackling and sorting are, so far as our purposes are concerned, practically the same. The amount of dust varies according to the condition of the material, but in all much of an injurious nature is given off.([a])

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[a] Privy Council Medical Report, 1860, pp. 148–152.

The report calls attention to the fact that even at the present time in not a single instance, either in hand-hackling rooms or in machine-hackling rooms, are respirators provided for the use of workmen, and it is suggested that a special rule be adopted making it mandatory that "suitable and efficient respirators shall be provided for the use of the persons employed in roughing, sorting, hand or machine hackling, preparing, and carding." In the inspector's opinion, "Cloth of open texture, made of fine yarn of woolen material, capable of being easily washed, makes an excellent respirator, which can be worn with advantage and without discomfort."

A special investigation into the conditions of work in flax and linen mills, including a thoroughly qualified scientific analysis of the air in flax mills, was made by the Pathological Laboratory of Louvain, the center of the flax industry in France. This investigation proved that the chief constituent of flax dust is mineral matter, the proportionate amount of which varies with the condition of the flax in the different processes, being largest during the process of carding, where it was found to be about four times as large in flax dust as in the outside atmosphere. In addition, it was ascertained that the number and proportion of micro-organisms in flax dust were enormously in excess of the corresponding proportion found in the outside atmosphere, the excess being most pronounced in the dust produced during the hand hackling. The dusty processes in the order of their importance were determined by this investigation to be, first, carding; second, machine hackling; third, preparing; and fourth, hand hackling. Those containing the largest amount of micro-organisms, in the order of their importance, were, first, hand hackling; second, carding; third, machine hackling; fourth, preparing; fifth, spinning; and sixth, reeling. The cause of the injurious nature of the flax dust previously referred to as being very largely of mineral origin was ascertained to be the considerable proportion of silica. The health-injurious conditions in the different rooms were discussed briefly, as follows:

The hackling rooms, both hand and machine, are described as very dusty. Their condition explains the ill health of the workers and the rapid elimination of the workers which takes place. As an additional cause, reference is made (with quotations from the writings of the late Dr. C. D. Purdon, of Belfast, and Doctor Arlidge) to the arduous nature of the work in the machine-hackling rooms, the nature of the work not admitting of a moment's relaxation on the part of the boys employed.

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[a] Report upon the Conditions of Work in Flax and Linen Mills, by Hamilton P. Smith, p. 10. London, 1904.

The carding rooms are described as so dusty that the workers appear to work constantly in a mist. It is held to be the most unhealthy occupation from which results a rapid elimination of workers, only those of strong constitution being able to continue at it. Despite this, the unhealthy nature of the work leads to illness frequently and causes others to abandon the work. The average duration of employment is the shortest, and yet the sickness among the workers is the greatest. As possibly causing the dust of the carding rooms to be more injurious than that of any other, reference is made to the metal particles which must be present in the air from the wearing away by friction of the numerous teeth on the carding machines.

Work in the preparing rooms is not considered to be comparable as regards injury to health with those described, and it is pointed out that the figures as to the amount of dust and of micro-organisms present in the air are to some extent vitiated by the fact that carding and preparing are sometimes carried on in the same room.

Reeling is not an injurious occupation; what injury to health there is arises from the humidity of the atmosphere. As a subsidiary cause of ill health in these rooms, is the fact that some of the machines are only capable of being kept in motion by the foot being pressed continually on a bar underneath the machine. This necessitates continuous strain on the muscular system.(a)

It is a matter of regret that there should be no very conclusive statistical data regarding the apparently very serious health-injurious effects of linen and thread manufacture, and in the absence of such data, especially for the United States, no definite and conclusive opinion would be warranted, although the general observations sustain the conclusion that the labor conditions in this industry are very far from being what they should be to reduce the health-injurious effects of the various employments to a minimum.

HEMP AND CORDAGE MANUFACTURE.

The manufacture of cordage ranks first in the group of miscellaneous textile products, but the industry never has attained to as large proportions in the United States as the home market alone would seem to warrant. With the introduction of machinery the earlier ropewalks have nearly disappeared and conditions otherwise

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[a] Report upon the Conditions of Work in Flax and Linen Mills, by Hamilton P. Smith, appendix 7, pp. 22, 23. London, 1904.

in this employment have undergone material changes. In the rope-walks very common to an earlier period it was the practice, according to Clark, for a man to walk forward and backward, spinning from the hemp around his waist, the twist being imparted from a wheel turned by a boy. Occasionally this practice is still followed at the present time. That the employment was more or less injurious to health is pointed out by Thackrah, and commented upon in Hall's Journal of Health in 1832, where it is stated that "ropewalkers suffer inconvenience from their stooping position." In the modern rope factory the twist is imparted by rapidly rotating machinery similar to that used in textile mills generally, making it possible, in the words of Clark, "to spin a rope several thousand feet in length on an upright apparatus occupying but a few square feet."

The descriptive account of the processes and circumstances under which the work is carried on fully sustains the view that a not inconsiderable amount of dust is generated during practically every important process, and without question more or less to the injury of the health of the employees. In discussing the hygiene of this occupation much emphasis is placed upon the specific processes necessary for the successful preparation of the hemp, flax, jute, and other fiber. The subject is referred to in a special report of the Massachusetts state board of health, which is in fact the only really trustworthy account of present-day conditions in this employment. Referring to the manufacture of cordage, twine, carpet yarn, and gunny bags the report states that:

> The raw material in various forms comes in bales, which are opened and shaken apart, and the contents are then treated according to their nature. Ordinary jute and hemp, after being shaken out, are run through softening machines, in which they are moistened with an emulsion of oil and water, preparatory to carding. Old rope, gunny bagging and twine are run through machines which pick the fibers apart as a preliminary to other processes. Opening, picking, softening and carding are processes which are exceedingly dusty, and the dust is very irritating to the air passages. The machines which straighten and twist the fibers also give rise to much dust.

Arlidge reports upon the conditions in this employwment as follows:

> The manufacture of rope and other cordage, formerly carried on after a primitive fashion in "ropewalks," to be found in every town, has become greatly transformed by the introduction of machinery. The great rope-making establishment at Belfast has almost annihilated every ropewalk in Ireland, and seems in a fair way of doing the same thing for England.
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> The hemp, Russian or Manila, is worked on the same general lines as flax. It has first to be sorted and picked over by girls, hand-roughed and heckled, then carded and a sliver formed, which, after a certain degree of twisting in the roving frames, is submitted to the spinning machines. Both the wet and dry processes are used, the

former principally for the fine yarn. The spun yarn is next taken to large tanks of boiling tar, through which it is slowly passed; this done, the superfluous tar is pressed out between iron rollers, and the yarn afterwards slowly dried. The next business is the twisting of the yarn into strands, on the old ropewalk principle, but by the aid of machines. Cord made from harsh fibers has to undergo a scouring process, prior to sizing and polishing, to fit it for market.

This outline of the processes conveys the general hygienic features of rope making, and at two points at least, viz, in the sorting and the heckling and preparing rooms, the evil of dust arises just as in working flax for linen, in no small degree, with its inevitable consequences to the respiratory organs.

Parry also refers to this occupation, and with special reference to health-injurious consequences incidental to the manufacture of rope or cordage. He points out that—

> Hemp is used for ropes, cords, and carpets. The manufacture is much the same as jute. No heckling machines are used. In carpet making the hemp is cut into 12-inch lengths, oiled, and then scutched, carded, and arranged in slivers. The coarse fibers and woody matters are removed, and the rest converted into tow. The slivers are made into large bales, which are again passed through the finishing card, by which fresh tow is separated. Wool is also an important ingredient in this industry. After the hempen foundation is made, short-fibered coarse wool, wound on bobbins, is woven in. All these processes produce dust of hemp and wool; especially is this noticed during the emptying of the tow box, and also during the dressing process, particularly of hemp imported into this country.
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> The hemp must be sorted and picked over, hand roughed and heckled; then carded and a sliver formed, twisted and spun either by the wet or dry process. In all the early stages, especially sorting and heckling, dust is produced just as it is in linen making.

Contrasting present-day conditions in rope manufacture with the earlier and very primitive processes common to all ropewalks, it is somewhat doubtful whether the change to the almost universal use of machinery has been really a benefit to the occupation. The necessity of walking forward and backward in the old-fashioned ropewalk no doubt was of great value as a matter of mere physical exercise, but no conclusive observations have been made a matter of record which would warrant a definite opinion as to whether conditions at the present time in ropewalks are better or worse than those prevailing at former periods.

The occupation mortality statistics of cordage workers are limited to English sources since no data have been made public regarding the mortality of this occupation in the United States. The number of male wage-earners employed in this industry in the United States in 1905 was 8,646, a sufficient basis for a safe generalization if the necessary mortality data were available. The reference to the mortality of rope makers in the Supplement to the Sixty-fifth Annual

Report of the Registrar-General for the three years ending with 1902 is in part as follows:

> The number enumerated in this occupation was only 6,255 at the last census, the number being too small to warrant detailed examination. As compared with the standard for occupied and retired males the death rates fluctuate widely. In the main working time of life the comparative mortality figure is 910, or 9 per cent less than the standard, and under each heading except phthisis they suffer less than the average mortality.([a])

The recent English statistics for this occupation are quite conclusive of the unfavorable effects of the employment on health at ages 20 to 34 and at 55 or over. In the table which follows a comparison is made of the mortality from all causes of men in this group with occupied males generally, and while the differences are not very pronounced at the earlier ages, they indicate the facts at least with approximate accuracy, and the comparison is, therefore, quite suggestive.

MORTALITY FROM ALL CAUSES AMONG MALE **CORDAGE MAKERS,** COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 for all occupied males.	Death rate for male cordage makers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	2.44	2.20	− 0.24	90
20 to 24 years	4.41	5.75	+ 1.34	130
25 to 34 years	6.01	6.47	+ .46	108
35 to 44 years	10.22	7.45	− 2.77	73
45 to 54 years	17.73	13.03	− 4.70	73
55 to 64 years	31.01	32.49	+ 1.48	105
65 years or over	88.39	105.86	+17.47	120

The preceding table is self-explanatory and requires no further comment. A more extended comparison, however, is made in the next table, in which the mortality of cordage makers from consumption is compared with the normal mortality of occupied males, by divisional periods of life. The comparison shows that the mortality from consumption is excessive at ages 20 to 34 and 55 or over, or at the same age period at which the general death rate of cordage makers is in excess of the normal mortality of occupied males.

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[a] Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales, p. lxxxix.

MORTALITY FROM CONSUMPTION AMONG MALE **CORDAGE MAKERS**, COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Mortality from consumption.			
	Death rate per 1,000 for all occupied males.	Death rate for male cordage makers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	0.54	0.24	−0.30	44
20 to 24 years	1.55	2.09	+ .54	135
25 to 34 years	2.03	2.59	+ .56	128
35 to 44 years	2.74	2.48	− .26	91
45 to 54 years	3.04	1.18	−1.86	39
55 to 64 years	2.16	3..77	+1.61	175
65 years or over	1.11	1.50	+ .39	135

The industrial insurance mortality experience of rope makers is limited to 109 deaths from all causes. Of this number, 28, or 25.7 per cent, were from consumption, and 9, or 8.3 per cent, were from respiratory diseases other than consumption. Of the deaths from other respiratory diseases, 6 were from pneumonia, 1 from asthma, and 2 from bronchitis. The following table gives an extended comparison of the mortality of rope makers from consumption with the normal mortality of all males in the registration area of the United States for the seven-year period 1900 to 1906.

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG **ROPE MAKERS**, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for rope makers from experience of an industrial insurance company; figures for males in registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of rope makers, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Rope makers.	Males in registration area, 1900 to 1906.
15 to 24 years	12	6	50.0	27.8
25 to 34 years	18	9	50.0	31.3
35 to 44 years	17	7	41.2	23.6
45 to 54 years	18	6	33.3	15.0
55 to 64 years	24	....	....	8.1
65 years or over	20	....	....	2.7
Total	109	28	25.7	14.8

These statistics show an excessive mortality from consumption among rope makers, and this excess is specially high at the younger ages. One-half of the total mortality was due to consumption at ages 15 to 24 and 25 to 34, against an expected proportion of 27.8

and 31.3, respectively. While the statistics are limited to comparatively small numbers, the facts are decidedly suggestive of health-injurious conditions in the rope-making industry.

The observations and statistical data regarding the mortality of cordage makers, while not entirely conclusive, indicate with at least approximate accuracy the high degree of consumption frequency at ages 20 to 34 and at 55 or over. It is quite probable that changes in occupation affect the official vital statistics of this trade to a sufficient extent to understate the true effect of the employment on health. There would therefore appear to be unfavorable conditions in this employment, doubtless largely due to the exposure to vegetable fiber dust, resulting in a comparatively high degree of consumption frequency among the employees.

MANUFACTURE OF JUTE AND JUTE GOODS.

The manufacture of jute and jute goods in 1905 gave employment to 6,083 wage-earners, but of this number only 2,437 were men, while 3,083 were women, and 563 were children under 16 years of age.([a]) The industry is practically new in the United States, and as yet only a beginning has been made in its development, but it is significant that there has been an increase of 50 per cent in the number of wage-earners employed in the manufacture of jute and jute goods during the five years ending with 1905. No vital statistics have been published for this industry as it is carried on in the United States, but some reference will subsequently be made to the official statistics of Scotland, where the industry has attained to very considerable proportions.

A brief description of jute manufacture was included in Bevan's account of the manufacturing industries of the United Kingdom, and while the description is of somewhat early date it applies to present-day conditions, which in the meantime have not undergone a material change:

> Formerly jute used to be spun as flax, which it resembles in fiber, though much coarser. It was heckled, so as to get as much as possible of the fine fiber, and separate it from the coarse. The latter, however, so greatly predominated that it was found to be a useless expense, and it was, therefore, treated like tow, and placed at once in the carding engine. As it is even coarser than tow, one would naturally think that more dust would arise, and that the trade would surpass the flax trade in unhealthiness; but this is not so, owing to the necessity for saturating the jute with oil, so as to make the coarse and brittle fibers flexible. Its very roughness, therefore, has proved a sanitary safeguard to the workers.

Bevan enumerates 20 subdivisions of labor in jute manufacture, but he does not enlarge upon the health-injurious conditions incidental to the different employments. On the whole, however, the subdivisions of labor in jute manufacture correspond to those in textile manufacture generally The most serious factor injurious to health in jute manufacture is the dust problem, which under most favorable circumstances, however, is subject to material modification. The dust of jute under the microscope, according to Oliver, shows "vegetable fibers which are often torn and ragged and therefore with difficulty detached from the bronchial mucous membrane."

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[a] Census of Manufactures, 1905, Part III, p. 190.

The hygiene of this employment has been discussed by various authorities, and an excellent account of the conditions affecting the health of persons employed in jute manufacture in Dundee, Scotland, was contributed to Oliver's "Dangerous Trades," by Mr. Harry J. Wilson, one of His Majesty's inspectors of factories, from which in part the following extracts are made, emphasizing the more dusty processes of this occupation:

> The first operation in the process of the manufacture of jute consists in cutting the binding ropes of the bale and opening out the hard, compressed material. This is invariably done by hand, and immediately afterwards the fiber, still in a compressed state, is passed through between four heavy deeply-fluted rollers intersecting each other, which open the material somewhat and facilitate its disentanglement, before it is placed on the feeding table of the softener. During these processes, while the fiber is in a dry condition, a considerable quantity of dust is shaken out, much of it being of a gritty nature and consisting largely of fine particles of the sand or mud in which the plant grows. The latter impurities adhere to the rooty portion of the plant, but becomes dispersed when the fiber is shaken out and disturbed. It is in this dust that tetanus spores have been found in very considerable quantities. * * * As matters at present stand, the preparing operations in jute factories are much more dusty than subsequent processes, but the particles thrown off in carding, drawing, and rove spinning are more of a light, fluffy nature, and prove less irritating to the respiratory organs than the gritty dust evolved in handling the dry jute. After the material has been effectively softened, and while in a slightly moist condition, it is fed into the "breaker" card. Here, owing to the splitting and combing action of the rapidly-running card teeth, many rooty particles and other impurities are removed, but the heavier matter falls below the machines, from which it is taken away periodically, so that only the lighter dust rises and is breathed by the operators.
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> The operations subsequent to carding evolve little dust relatively, but owing to the excessive speed of spinning-frame flyers and the friction on the yarn, very light, fluffy particles are continually rising in spinning rooms, so that the atmosphere becomes charged with extremely fine portions of fiber. All horizontal surfaces and the clothing and hair of the workers in these departments soon become coated with this dust.
>
> The dirtiest and most objectionable processes in the manufacture of the material are undoubtedly those of preparing and spinning. The remuneration of the operatives in these departments is consider-

> ably less than that earned by the weavers. Thus a distinctly lower class of employees engage in the former processes, the more self-respecting taking up weaving as a means of livelihood.
>
> Where the finer qualities of fiber are treated, the amount of dust evolved is comparatively small, and the factories fairly clean; but in the coarser varieties it becomes excessive and the whole premises assume a dirty and objectionable aspect. It may be of interest to observe here that many women engaged in the preparing and spinning operations of jute manufacture habitually snuff, presumably to rid the nostrils of dust. The custom is rarely observed among women outside Dundee.
>
> The prevention of the dispersal of dust in carding and spinning is extremely difficult, for it appears to rise, more or less, from the fiber, wherever it is sufficiently disturbed, and from any number of points, even in one room. Exhaust fans, however, when placed immediately above the softening machines and properly erected, undoubtedly remove much of the fine, gritty particles shaken out of the raw material, and where a hood is arranged above the exact seat of dust production and communicates with a fan, there is little to complain of.
>
> This particular dust from the raw material is most irritating to breathe, and is presumably injurious, but fortunately few persons in any one mill come in contact with it.

To quote further, the following remarks refer to the high temperature and other conditions injurious to health in jute spinning rooms:

> Unquestionably the high temperatures of spinning rooms are distinctly harmful, perhaps more so than is usually imagined. In fact, the writer, from close observation of operatives in various parts of the country and in dissimilar industries exposed persistently to warm atmospheres, is of opinion that a general lowering of the health (in certain instances marked) very frequently follows such employment. The effects of constantly breathing warm air, quite apart from the liability to chills which such atmospheres engender, are worthy of closer study and scientific investigation. Certainly exposure to great radiated heat, if the air is not particularly warm, does not affect workmen in a similar manner.

The opinion of Wilson, based upon personal investigation, is to the effect that the weaving of jute is apparently a healthy occupation, judging from the general appearance of the operatives. Most of these operatives are women, including sack sewers, who as a rule present a ruddy and robust appearance. The disease liability of jute workers employed in spinning and preparing rooms to pulmonary diseases is also discussed by Wilson, who incidentally comments upon other factors injurious to health as follows:

> Investigations reveal a predisposition among factory workers, and particularly those employed in spinning and preparing rooms, to develop respiratory troubles, broncho-pneumonia, chronic bronchitis, and pulmonary emphysema being the most prominent. There is also a singularly large number of patients admitted to the local infirmary suffering from lobar pneumonia. Rheumatism is an extremely common ailment, and can be partially accounted for by the great variations of temperature which operatives have frequently to withstand.

> Multiple tuberculous lesions are frequently observed in the children of the poorer operatives, and thus one finds from time to time young persons at work with portions of the hands amputated on account of scrofulous or tuberculous diseases of the bones. Slight deafness is widespread among jute operatives, but other textile workers may be afflicted in a similar degree. The excessive noise of jute-weaving looms and the persistent loud hum of spinning frames presumably account for much of this. The looms, owing to their large size and the weight and high speed of the shuttles, are particularly noisy. The possibility of the dust inducing the formation of an obstruction with the waxy secretion of the ear is not excluded. Indeed, the fine light particles of fiber readily accumulate in the external auditory canal.
>
> A hoarseness or huskiness of voice is met with frequently, and is especially marked in preparing and spinning operatives. Whether this is due to overstraining of the voice, shouting above the noise of the machinery, or to dust irritation of the vocal chords has never been clearly demonstrated. Anæmia in its commonest forms is a frequent ailment among all the operatives, but doubtless careless and injudicious feeding contributes to this condition of health.

Wilson describes the occurrence of "mill fever," so called, which no doubt contributes in a measure toward a predisposition to respiratory and tubercular diseases, as follows:

> An illness locally known as "mill fever" attacks about one-fourth of the persons who commence labor in factories for the first time. The symptoms make their appearance a few days after work is started and take the form of one or more of the following: Headache, backache, lassitude, thirst, and slight fever. The attack lasts about from three to four days and yields to antifebrile medicines, followed by tonics. It has been observed that the patients are usually young people and are frequently of weak constitution or badly nourished.

In summing up his conclusions this authority calls attention to the difficulty of differentiating with accuracy between the health-injurious effects properly to be charged to the industry and the effects of poor feeding and bad housing, which no doubt are of considerable importance in Dundee, since the low physical and social condition of the operatives in jute factories is admitted to be a marked feature of the industry. In conclusion, Wilson refers to the health conditions in jute manufacture in East India, where the industry has developed to large proportions, stating that:[a]

> The reports of the inspectors of jute mills in East India show that the industry is considered there to have no particularly deleterious effects on health. The mills, however, are built with very high roofs and are largely open to the sky. The climate permits of this, and accordingly the ventilation gives no trouble. Another fact has to be borne in mind in comparing Indian operatives with those employed at home. The former are migratory, only remaining a year or two at the industry, and, presumably, insufficient time is given for any in-

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[a] Mention may also be made here of a recently published report of the East India Factory Labor Commission, Vol. I, Parliamentary Paper CD-4292. London, 1908.

jurious effects to betray themselves; whereas in Scotland the bulk of a lifetime is spent by a worker in a jute factory.

The conclusions of Wilson are fully sustained by other qualified observers, and an account by Arlidge of this employment is included in this review of qualified medical opinions regarding the health-injurious conditions in this industry:

> In general principle the processes resemble those in use in making linen, but as the fibers of jute are coarser, longer, and more brittle than those of flax slight differences exist in the mechanical operations. Hackling is, of recent years, not employed, but the jute is at once sent to the carding machine. But what would be a most dusty and injurious operation is rendered comparatively harmless by the previous profuse sprinkling of the jute with water and train oil, for the purpose of rendering the fibers more flexible. This preparatory moistening and softening of the material is an advantage in the subsequent operations of preparing and spinning, by reducing greatly the amount of dust that this harsh substance would otherwise give off. Nevertheless, I have seen jute in the course of spinning give off much coarse dust, and should anticipate that could the statistics of the jute manufacture be got at they would, on the whole, exhibit still more insanitary results than do those of the linen trade.

It is only for Scotland that the vital statistics of workers in jute have been separately recorded, but it is somewhat doubtful whether employment in the industry is sufficiently permanent to warrant final conclusions. During the three years ending with 1892 there occurred in Scotland 132 deaths of jute workers ages 25 to 64, and of this number only 26, or 19.7 per cent, were from consumption. There also occurred 20 deaths from bronchitis, 15 from pneumonia, and 4 from other respiratory diseases, a total of 65 deaths from diseases of the lungs and air passages, or 49.2 per cent of the mortality from all causes. In commenting upon the mortality of persons employed in the manufacture of jute, the Supplement to the Thirty-eighth Annual Report of the Registrar-General of Scotland states that diseases of the respiratory system and phthisis are especially prominent as causes of death, and that to these diseases may be added diseases of the nervous and circulatory systems. If, however, the general death rates of jute workers are compared with the corresponding mortality of males generally, the rates are rather below than above the average except at ages 15 to 19. This rather unexpected result is no doubt due in part to occupation selection, but as has been previously pointed out, the class of labor employed in jute manufacture in Scotland is of a decidedly low order. The details of the mortality for three years ending with 1892 are set forth in the following table, which has been abstracted from the report (p. lxxi) previously referred to;

MORTALITY OF MALE EMPLOYEES IN **JUTE MANUFACTURE** IN SCOTLAND, 1890 TO 1892.

[From the Supplement to the Thirty-eighth Annual Report of the Registrar-General of Births, Deaths, and Marriages of Scotland.]

Age.	Years of life. (a)	Deaths.	Rate per 1,000.	Rate per 1,000 for all employed males.
15 to 19 years	7,077	37	5.23	5.72
20 to 24 years	3,180	25	7.86	7.53
25 to 44 years	5,259	38	7.23	9.98
45 to 64 years	2,568	94	36.60	24.34
65 years or over	441	37	83.90	99.58

[a] The years of life as used in this table means three times the number of employees in jute manufacture enumerated at the census of 1891.

The Supplement to the Forty-eighth Annual Report of the Registrar-General of Scotland, published in 1905, comments at greater length upon this employment, and again the statistical data contradict some of the previously quoted medical conclusions unfavorable to the industry. According to the report, males in jute manufacture experienced death rates at ages 25 to 44 and 45 to 64 below the corresponding death rates of all males in Scotland. At ages 25 to 64 there occurred 145 deaths from all causes among jute workers, and of this number 26, or 17.9 per cent, were from consumption and other tubercular diseases, while 19 were from pneumonia, 12 from bronchitis, and 3 from other respiratory diseases, a total of 60 deaths from diseases of the lungs and air passages, or 41.4 per cent of the mortality from all causes. The facts in detail regarding the general mortality of jute workers, by divisional periods of life, for the three years ending with 1902, are set forth in the table below, which has also been abstracted from the report (p. cxxvii) previously referred to:

MORTALITY OF MALE EMPLOYEES IN **JUTE MANUFACTURE** IN SCOTLAND, 1900 TO 1902.

[From the Supplement to the Forty-eighth Annual Report of the Registrar-General of Births, Deaths, and Marriages of Scotland.]

Age.	Years of life. (a)	Deaths.	Rate per 1,000.	Rate per 1,000 for all employed males.
15 to 24 years	12,213	57	4.67	....
25 to 44 years	9,294	59	6.35	9.32
45 to 64 years	4,740	86	18.14	26.82
65 years or over	888	61	68.69	....

[a] The years of life as used in this table means three times the number of employees in jute manufacture enumerated at the census of 1901.

The available statistical data do not warrant a definite conclusion at the present time, but the observed conditions in the industry suggest that the same may safely be classed among the dusty trades more or less injurious to health and predisposing to consumption.

PAPER AND PULP MANUFACTURE.

The manufacture of paper and wood pulp, according to the census of 1905, gave employment to 65,964 wage-earners, the number of which had increased 33 per cent during the preceding five years. The industry is concentrated in large plants, in which, broadly speaking, the conditions of work, with particular reference to disease and exposure to other health-injurious circumstances, are more satisfactory than in small establishments. The industry has undergone a marked change within recent years, and the predominating material used in manufacture now consists of wood pulp, in place of linen rags, which in the past constituted the sole material from which paper was made. Among other materials which are at the present time employed in paper manufacture, aside from wood pulp, are chiefly rags, including cotton and flax waste and sweepings, manila stock, including jute, bagging, rope, waste, threads, and straw, which last is being employed to an increasing extent, including the rice straw of the Southern States.

The most important dust-producing material is rags, which, as a rule, however, are subjected to a preliminary sorting process outside of paper mills. A careful sorting process is necessary to eliminate colored rags, which are not adapted for white paper making, all of which is carried on in the rag and sorting rooms, which form the dustiest section of a paper mill. The sorting and the transfer of the rags to the cylinders in which they are boiled under high pressure with caustic soda are, according to Arlidge, the only important processes in which dust is set free except at the tear-up machines and to a limited extent in the bleaching department, where there is often a diffusion of the dust of bleaching powder, which, however, can be prevented by previously moistening it, which is often the case.

The health-injurious aspects of the industry are referred to in a report of the Massachusetts state board of health to the effect that—

> The operatives engaged in certain of the processes of paper making are exposed to considerable dust from rags used in the manufacture; those engaged in other departments are exposed more or less to wet; and those in still others are exposed to no industrial dangers whatever. The most important department of such a mill, from a sanitary standpoint, is the rag-sorting room. In most of the mills visited provision exists for carrying away, by mechanical ventilation, the dust arising from the handling of the rags; in some, no provision whatever is made. On account of the nature of the raw material, it is generally thought that there is some risk of infection of those who handle the rags, and smallpox is everywhere looked upon as one of the most important possible dangers of the paper industry. It would appear, however, from facts obtainable, that cases of infection traceable to the handling of rags are not common. In some of the establishments, it is said, the rag sorters are seldom sick. In the establishments visited the operatives had generally the appearance of health and strength.

In a subsequent report by the same authority the dust problem in paper manufacture is discussed at greater length, in part as follows:

> The materials from which paper is made include rags, burlap, old paper and wood pulp. Rags are derived chiefly from foreign countries, from which they are imported in bales compressed by hydraulic power. These are opened at the mill, and the contents are put into a closed, box-like structure, known as a "beater" or "thresher," containing a large wooden roller with iron "fingers," which revolve several hundred times per minute. This separates the rags and shakes them thoroughly, giving rise to much dust, which falls between the long strips of iron grating beneath the roller into a specially constructed receptacle, which may be cleaned out by hand or by means of an exhaust fan and dust pipe. During this process more or less dust commonly escapes into the room, and in some instances the amount is very great, partly because of the very dirty character of the rags handled. From facts gathered with reference to this process in 80 establishments it appears that, with the usual grade of stock, no matter what kind of "duster" or "thresher" is used, and in spite of exhaust fans and dust pipes, some dust will escape. With high-grade stock certain dusters work very well, while with low-grade stock the results are far from satisfactory. Some very high-grade clean stock gives off little if any dust.
>
> In some mills the dust from the threshers is collected and baled. This work is exceedingly dusty, and the men who perform it are provided with respirators, which they appear to use with far less reluctance than is shown by those to whom they are supplied in other dusty trades.
>
> From the duster or thresher the rags are conveyed by hand or through a chute to the sorting room, where they are sorted on tables with box-like tops provided with bottoms of wire netting, through which dust and fine particles escape to receptacles below.

The most recent English mortality statistics of paper manufacture are for the three years ending with 1902, referred to in the Supplement to the Sixty-fifth Annual Report of the Registrar-General in part as follows:

> At ages under 20 years paper makers experience a mortality considerably above, and at ages over 65 years slightly above, the standard for occupied and retired males; at all other ages it is below the standard, the difference being most marked at ages 35 to 55 years. In the main working period of life the comparative mortality figure is 730, or 27 per cent below the standard. The mortality from influenza, alcoholism, and liver disease, and accident is in each case less than half the standard, and under every other heading except suicide there is also an advantage.([a])

The recent English mortality statistics for persons employed in the paper industry do not indicate a very marked effect of this employment on health, but rather to the contrary the general death rate was below the average at ages 20 to 64. In the table which follows a comparison is made of the mortality from all causes among men in this group with that of occupied males generally, and the comparison shows that it is only at ages 15 to 19, and 65 or over, that the general death rate of persons employed in paper manufacture exceeds the general average.

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[a] Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales, p. xci.

MORTALITY FROM ALL CAUSES AMONG **PAPER MAKERS**, COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 for all occupied males.	Death rate for paper makers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	2.44	3.46	+1.02	142
20 to 24 years	4.41	4.01	− .40	91
25 to 34 years	6.01	5.02	− .99	84
35 to 44 years	10.22	6.66	−3.56	65
45 to 54 years	17.73	11.05	−6.68	62
55 to 64 years	31.01	26.38	−4.63	85
65 years or over	88.39	94.80	+6.41	107

The preceding table is self-explanatory and requires no further comment. A more extended comparison, however, is made in the next table, in which the mortality of paper makers from consumption is compared with the normal mortality of occupied males from this disease, by divisional periods of life. The comparison shows that the mortality from consumption was below the average at all ages.

MORTALITY FROM CONSUMPTION AMONG **PAPER MAKERS**, COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Mortality from consumption.			
	Death rate per 1,000 for all occupied males.	Death rate for paper makers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	0.54	0.54	....	100
20 to 24 years	1.55	1.29	− .26	83
25 to 34 years	2.03	1.95	− .08	96
35 to 44 years	2.74	2.13	− .61	78
45 to 54 years	3.04	1.78	−1.26	59
55 to 64 years	2.16	1.86	− .30	86
65 years or over	1.11	1.02	− .09	92

The foregoing comparison indicates a degree of consumption frequency below the average for paper makers, but the differences are not very pronounced and at certain periods of life are very slight. It is quite probable that occupation changes affect the accuracy of the official vital statistics and that the health-injurious effects of the industry are more serious than is disclosed by an analysis of the available statistical information regarding this employment.

The recorded industrial insurance mortality statistics of paper makers are limited to 115 deaths from all causes, of which 34, or 29.6 per cent, were from consumption. Of the mortality of paper makers from respiratory diseases other than consumption, 9 were from pneumonia and 1 was from bronchitis. There were 44 deaths of paper makers from consumption and from other respiratory diseases combined, or 38.3 per cent of the total mortality was due to diseases of the lungs and air passages. The excess in the mortality of paper makers from consumption is clearly brought out in the tabular presentation of the proportionate mortality from this disease, by divisional periods of life.

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG **PAPER MAKERS**, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for paper makers from experience of an industrial insurance company; figures for males in the registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of paper makers, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Paper makers.	Males in registration area, 1900 to 1906.
15 to 24 years	13	6	46.2	27.8
25 to 34 years	28	15	53.6	31.3
35 to 44 years	18	7	38.9	23.6
45 to 54 years	15	2	13.3	15.0
55 to 64 years	23	3	13.0	8.1
65 years or over	18	1	5.6	2.7
Total	115	34	29.6	14.8

While according to this table the consumption mortality of paper makers was excessive at all ages except 45 to 54, the excess was most pronounced at ages 15 to 44. At ages 15 to 24, out of every 100 deaths from all causes, 46.2 were from consumption, against 27.8 expected; at ages 25 to 34 the proportion was 53.6, against 31.3 expected; and at ages 35 to 44 the proportion was 38.9, against 23.6 expected.

CABINETMAKERS.

The occupation of the cabinetmaker is a well-defined and separate branch of carpentry practically limited to the manufacture of furniture, and men in this employment are often separately classified as furniture makers and repairers. Occasionally the classification includes upholsterers, but since the exposure to health-injurious conditions is essentially different in the two occupations, such a grouping is not in conformity to the conditions under which the two employments are carried on. The census of 1900 returns the number of cabinetmakers at 35,641, but in addition the number of persons employed in furniture manufacture was 23,078. In the vital statistics of the census of 1900, however, cabinetmakers and upholsterers are combined into one group, but the mortality returns were limited to the registration States, giving the combined number of the two employments for known ages 15 years or over as 24,695. Among this number there occurred during the census year 446 deaths from all causes, or at the rate of 18.06 per 1,000 per annum, against a general average for all occupations of only 15.16. The mortality from consumption among cabinetmakers and upholsterers, according to the census, was excessively high, or 3.59 per 1,000, against 2.37 for all occupations, and 2.62 for the manufacturing and mechanical industries class. The consumption mortality of cabinetmakers and upholsterers was also decidedly in excess of the corresponding mortality of carpenters and joiners. While the consumption mortality rate for cabinetmakers and upholsterers was 3.59 per 1,000, as previously stated, the corresponding rate for carpenters and joiners was 2.31. It is also of interest to note that while among cabinetmakers and upholsterers the proportion of persons of ages 65 or over was 6 per cent, the corresponding proportion for carpenters and joiners was 7.9 per cent. If the two employments had been separately returned the value of the data would have been very materially increased. It is quite safe to assume, however, that of the two occupations, that of the upholsterer is more injurious to health than the employment of the cabinetmaker.

Qualified medical opinion is divided as to the health-injurious effects of the continuous inhalation of wood dust, but it is generally agreed that the dust of hard wood is more injurious than the dust of soft wood, and that the most injurious of all is the dust of so-called satinwood, or African boxwood, which, however, is used in only very limited quantities for special purposes, which will be referred to again under wood turners and other woodworkers subsequently to be mentioned.

Ramazzini held the opinion that workers in wood do not suffer any serious inconvenience on account of their employment, except those working in cypress, which produces headache, an opinion which does not seem to be confirmed by extensive experience in our numerous cypress shingle mills. At least no qualified medical opinion has been made a matter of record, to the effect that employees in cypress mills are subject to particularly injurious conditions. Thackrah, writing in 1832, refers to health-injurious consequences among men working in particular kinds of hard wood, and his opinion is here quoted, since it was fully confirmed by subsequent experience. "Cabinetmakers suffer from the dust when they saw African, cam, rosewood, and Spanish mahogany. The first of these is most injurious. Its dust produces sneezing, headache, sickness, and sometimes vomiting. This wood, however, is rarely used."

B. W. Richardson, M. D., also commented upon wood dust as more or less injurious to health and as a substance injurious to the lungs, stating that—

> The dusts of some kinds of wood, to which turners of wood and fine cutters of wood are exposed, are causes of much irritation of the lungs and of bronchial cough. The dust is fine and penetrating, and when it is from colored wood it imparts its own peculiar color to the bronchial secretion. I have seen these phenomena, markedly in the case of mahogany carvers, in those who carve ornaments for couches and other articles of furniture. The work gives rise to a great quantity of wood dust, which is constantly inhaled. In carving, the artisan has to keep up a blowing process with the lips in order to blow away the small portions of wood which he removes with the chisel. This process is very wearying, but the chief complaint made by the worker is of the dust he draws back in inhalation. The mischief is greatly increased in the rooms where the ventilation is imperfect. The cough is usually attended with copious secretion from the bronchial tubes, and I have more than once known the loss from this cause so copious as to cause other symptoms of wasting and exhaustion allied to phthisis pulmonalis and constituting what has been called bronchial phthisis. As a rule, however, those who suffer from this form of disease recover when they are removed from their occupation and are placed in favorable circumstances for recovery.

More recent observations are by Parry, who refers to the employment of cabinetmakers, but who, in particular, considers the process of sandpapering and the resulting mixture of mineral with organic dust. In his opinion, "carpenters, joiners, turners, and cabinetmakers are exposed to the risks of breathing in wood dust; but the lung-disease death rate—337 compared with 402 for all males—does not seem to prove that much harm is caused by its inhalation."

Tracy refers very briefly to the occupation, and after stating that dust of vegetable origin is on the whole quite harmless, holds, regarding the effect of wood dust in particular, as follows: "The workmen who inhale vegetable dust do not as a rule suffer in consequence. The dust of wood, in particular, is so harmless that it seems more appropriate to speak of cabinetmakers and carpenters under another heading, as their attitude while at work has more to do in bringing on disease than the atmosphere they breathe. The dust of the hard woods, as mahogany, rosewood, etc., may cause slight irritation of the larynx and trachea and a tendency to bronchial catarrh."

The annual reports of English factory inspectors contain frequent references to the health-injurious effects of African boxwood, or so-called satinwood, rosewood, etc., but since the manufacture of small articles in which this wood is used brings the employment more properly within the group of wood turners and carvers, the peculiar effects of the dust of this wood on health will there be considered in more detail.

As previously stated, the United States census returns combine the mortality of cabinetmakers with that of upholsterers; and the only official vital statistics are for the State of Rhode Island for the decade ending with 1906. The number of deaths of cabinetmakers recorded was only 50 from all causes, and of this number 12, or 24 per cent, were from consumption. The number of deaths from respiratory diseases other than consumption among men in this occupation was 9, which, combined with the mortality from consumption, returned 21 deaths from diseases of the lungs and air passages, or 42 per cent of the mortality from all causes. The corresponding percentage of deaths from consumption and from other respiratory diseases for all males in Rhode Island was 30.3 per cent.

The most recent English mortality statistics of cabinetmakers are for the three years ending with 1902, referred to in the Supplement to the Sixty-fifth Annual Report of the Registrar-General, in part as follows:

> Cabinetmakers suffer more severely than all occupied and retired males at ages under 20 and above 65, but at all intermediate ages the death rates are below the standard, while at every stage of life they exceed those of carpenters. In the main working period the comparative mortality figure of cabinetmakers is 956, or 5 per cent, below the standard. They suffer less than the average from influenza, alcoholism, and liver disease, as well as from diseases of the nervous, circulatory, and respiratory systems; the mortality from accident is also low. On the other hand, among these workers both cancer and phthisis are more fatal than the average, and suicide is more common.([a])

The recent English mortality statistics for cabinetmakers are not quite conclusive as to the generally unfavorable effects of this industry on health. In the table which follows a comparison is made of the mortality from all causes among men in this group with that of occupied males generally, and while the returns are not entirely conclusive they are suggestive of more or less unfavorable circumstances connected with the employment, since at ages 35 to 64 the departure from the normal is very slight and probably to a not inconsiderable extent the result of occupation changes more or less likely to impair the value of the available statistical data.

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[a] Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales, p. lxxx.

MORTALITY FROM ALL CAUSES AMONG **CABINETMAKERS,** COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 for all occupied males.	Death rate for cabinetmakers.		
		Rate per 1,000.	Greater (+) or less (—) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	2.44	2.61	+0.17	107
20 to 24 years	4.41	3.73	— .68	85
25 to 34 years	6.01	5.20	— .81	87
35 to 44 years	10.22	9.84	— .38	96
45 to 54 years	17.73	17.34	— .39	98
55 to 64 years	31.01	30.65	— .36	99
65 years or over	88.39	82.99	—5.41	94

The preceding table is self-explanatory and requires no further comment. A more extended comparison is made in the next table, in which the mortality of cabinetmakers from consumption is compared with the normal mortality of occupied males from this disease, by divisional periods of life. The comparison shows that the mortality from consumption was excessive at all ages, but in marked contrast to a low general death rate at ages 20 to 64. The corresponding death rates from consumption were excessive for cabinetmakers at all ages 15 or over. While the excess was not very marked, the departure from the normal is quite significant at ages 35 to 44.

MORTALITY FROM CONSUMPTION AMONG **CABINETMAKERS,** COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Mortality from consumption.			
	Death rate per 1,000 for all occupied males.	Death rate for cabinetmakers.		
		Rate per 1,000.	Greater (+) or less (—) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	0.54	0.69	+0.15	128
20 to 24 years	1.55	1.65	+ .10	106
25 to 34 years	2.03	2.18	+ .15	107
35 to 44 years	2.74	3.79	+1.05	138
45 to 54 years	3.04	3.83	+ .79	126
55 to 64 years	2.16	2.71	+ .55	125
65 years or over	1.11	1.86	+ .75	168

The recorded industrial insurance mortality statistics of cabinetmakers include 817 deaths from all causes. Of this number 162, or 19.8 per cent, were from consumption. In the mortality from respiratory diseases other than consumption there were 75 deaths from pneumonia, 14 from asthma, 14 from bronchitis, and 17 from other less frequent respiratory diseases. Of the total mortality 34.5 per cent was from diseases of the lungs and air passages. The mortality from consumption was excessive at all ages, but most so at 25 to 34, when out of every 100 deaths from all causes 55.7 were from consumption against a normal expected proportion of 31.3. The analysis of the mortality from consumption in detail is presented in the following table:

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG **CABINETMAKERS**, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for cabinetmakers from experience of an industrial insurance company; figures for males in the registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of cabinetmakers 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Cabinetmakers.	Males in registration area, 1900 to 1906.
15 to 24 years	39	14	35.9	27.8
25 to 34 years	61	34	55.7	31.3
35 to 44 years	82	40	48.8	23.6
45 to 54 years	136	31	22.8	15.0
55 to 64 years	197	29	14.7	8.1
65 years or over	302	14	4.6	2.7
Total	817	162	19.8	14.0

The observations and statistical data regarding the mortality of cabinetmakers confirm the conclusion that the degree of consumption frequency in this employment is decidedly excessive, and without question directly connected with the health-injurious circumstances of the trade. The excess in the degree of consumption frequency is most marked at ages 35 or over, which would make it probable that the type of the disease as met with in this employment assumes, in many cases, the fibroid form, or that of a distinct occupation disease.

WOOD TURNERS AND CARVERS.

Wood turning and carving are industries in which the conditions affecting health and life are much the same as in cabinetmaking and other woodworking industries. The amount of wood dust inhaled is probably larger, but no very conclusive information is available, with the exception of the health-injurious effects of working on so-called African boxwood, or satinwood, much of which is used for shuttle making. The effects of the dust, however, are probably not as serious to the lungs as to the system generally, and the most important effect of the dust of African boxwood is paralysis of the nerves. The whole subject was carefully considered before the commission on industrial diseases, and rules have been issued prohibiting the use of this wood, except under certain specified restrictions. The symptoms, as defined by Oliver, are similar to those occurring among cabinetmakers and joiners, who saw, chip, and otherwise manipulate the sequoia wood of our Pacific coast. It is stated that they resemble those exhibited by persons who are suffering from a bad cold in the head and chest, including irritation in the throat and bronchial tubes, accompanied by cough, labored breathing, and quickened pulse. The symptoms usually last only for a day or two and are usually seen only among men who are working with the wood for the first time. A tolerance seems to be established in regard to it, except in the case of men who are liable otherwise to bronchitis and asthma.

Oliver enlarges upon the subject and, after pointing out that certain kinds of wood have a bad reputation among joiners and that some sawdusts are more irritating than others, probably from the large amount of inorganic matter which they contain, he refers to conditions in Lancashire, where " the dust given off during the manufacture of shuttles for weaving purposes is a cause of malaise to the workmen employed. Many of them suffer from headache, coryza, excessive secretion of tears, and attacks of asthma." " The men who suffered presented a pale and jaundiced appearance; their breath had a peculiar camphor-like odor. Several of them had attacks of difficulty of breathing and of precordial pain accompanied by cold sweating. There was also marked slowing of the heart's action."

The health-injurious effects of wood working in hard woods, such as ebony and rosewood, have been recognized by different authorities on occupation diseases, and according to Arlidge of all woods rosewood produces the most obnoxious dust, emphasizing the fact that physical conformation and density of dust particles are not the sole factors governing the health-injurious effects on the human system.

The most recent English mortality statistics of wood turners and coopers are for the three years ending with 1902, referred to in the Supplement to the Sixty-fifth Annual Report of the Registrar-General in part as follows:

> At every group of ages except 15 to 20 years, the death rate exceeds the standard for all occupied and retired males, the excess being greatest in middle life. In the main working period the comparative mortality figure is 1,181, or 18 per cent above the standard. From all the principal causes, except accident, the mortality exceeds the average. Wood turners and coopers are specially liable to phthisis, as well as to diseases of the respiratory system and to Bright's disease.

The recent English statistics of wood turners are quite conclusive of the unfavorable effects of this industry on health. In the table which follows a comparison is made of the mortality from all causes among men in this group with that of occupied males generally, and the result is decidedly suggestive of conditions in the trade more or less unfavorable to life and health. The excess in the general death rate of wood turners is met with at all ages, but is most pronounced at ages 45 or over.

MORTALITY FROM ALL CAUSES AMONG **WOOD TURNERS,** COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 for all occupied males.	Death rate of wood turners.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	2.44	1.94	−0.50	80
20 to 24 years	4.41	4.46	+ .05	101
25 to 34 years	6.01	6.23	+ .22	104
35 to 44 years	10.22	11.69	+1.47	114
45 to 54 years	17.73	24.98	+7.25	141
55 to 64 years	31.01	34.70	+3.69	112
65 years or over	88.39	92.82	+4.43	105

The preceding table is self-explanatory and requires no further comment. A more extended comparison, however, is made in the next table, in which the mortality of wood turners from consumption is compared with the normal mortality of occupied males from this disease, by divisional periods of life. The comparison shows that the mortality from consumption was excessive at all ages, but decidedly so at ages 35 to 54, when the excess was 1.05 per 1,000 at ages 35 to 44 and 2.48 per 1,000 at 45 to 54.

MORTALITY FROM CONSUMPTION AMONG **WOOD TURNERS,** COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Mortality from consumption.			
	Death rate per 1,000 for all occupied males.	Death rate for wood turners.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	0.54	0.63	+0.09	117
20 to 24 years	1.55	1.54	− .01	99
25 to 34 years	2.03	2.89	+ .86	142
35 to 44 years	2.74	3.79	+1.05	138
45 to 54 years	3.04	5.52	+2.48	182
55 to 64 years	2.16	2.96	+ .80	137
65 years or over	1.11	1.36	+ .25	123

The recorded industrial insurance mortality experience of wood turners includes 127 deaths from all causes, of which 25, or 19.7 per cent, were from consumption. Of the mortality of wood turners from other respiratory diseases, 3 were from asthma, 2 from bronchitis, 11 from pneumonia, and 5 from less frequent diseases of this class. If the deaths from consumption and from other respiratory diseases are combined, 36.2 per cent of the mortality of wood turners was from diseases of the lungs and air passages. The number of deaths of wood turners included in this analysis is not quite sufficient for a final conclusion, but is decidedly suggestive of health-injurious circumstances destructive of life and health at an early period of life. The excess in the consumption mortality is more clearly brought out in the tabular presentation of the proportionate mortality from this disease by divisional periods of life. The comparison shows that the consumption mortality was decidedly excessive at all ages under 65, but most so at 15 to 34, when the proportionate mortality was 70 per cent at ages 15 to 24, and 62.5 per cent at 25 to 34.

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG **WOOD TURNERS,** 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for cabinetmakers from experience of an industrial insurance company; figures for males in the registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of wood turners, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Wood turners.	Males in registration area, 1900 to 1906.
15 to 24 years	10	7	70.0	27.8
25 to 34 years	8	5	62.5	31.3
35 to 44 years	17	3	17.6	23.6
45 to 54 years	24	4	16.7	15.0
55 to 64 years	33	5	15.2	8.1
65 years or over	35	1	2.9	2.7
Total	127	25	19.7	14.8

The recorded industrial insurance mortality experience of wood carvers may be separately considered, and the statistics available include 123 deaths from all causes. Of this number, 27, or 22.0 per cent, were from consumption, and 16, or 13.0 per cent, from respiratory diseases other than consumption. Of the mortality from other respiratory diseases, 9 deaths were from pneumonia, 2 from asthma, 2 from bronchitis, and 3 from less frequent respiratory diseases. If the deaths from consumption and from other respiratory diseases are combined, 35 per cent of the total mortality of wood carvers is shown to have been from diseases of the lungs and air passages.

The following table gives the details of the comparative mortality of wood carvers from consumption in the recorded industrial mortality experience:

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG **WOOD CARVERS**, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for wood carvers from experience of an industrial insurance company; figures for males in the registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of wood carvers, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Wood carvers.	Males in registration area, 1900 to 1906.
15 to 24 years	11	3	27.3	27.8
25 to 34 years	20	9	45.0	31.3
35 to 44 years	23	9	39.1	23.6
45 to 54 years	31	5	16.1	15.0
55 to 64 years	21	1	4.8	8.1
65 years or over	17	....	....	2.7
Total	123	27	22.0	14.8

The statistics for wood carvers do not show as great an excess in the mortality from consumption over the normal expected as was true of wood turners, but the excess is considerable, especially at ages 25 to 34 and 35 to 44. At ages 25 to 34, out of every 100 deaths from all causes 45 were from consumption, against 31.3 expected; at ages 35 to 44 the proportion was 39.1 for wood carvers, against 23.6 expected.

The observations and statistical data regarding the mortality of wood turners and wood carvers confirm the conclusions that the degree of consumption frequency in this employment is decidedly excessive and without question directly connected with the health-injurious circumstances of the trade. The excess in the degree of consumption frequency is most marked at advanced ages, which would make it probable that the type of the disease assumes in many cases the fibroid form or that of a distinct occupation disease.

SUMMARY OF CONCLUSIONS REGARDING OCCUPATIONS WITH EXPOSURE TO VEGETABLE FIBER DUST.

The occupations involving exposure to vegetable fiber dust have been considered in more or less detail. In this group, as in those exposing to metallic and mineral dusts, it has not been possible in all cases to base conclusions upon identical data, but the returns from the various available sources are sufficiently complete to be of considerable value. The census returns of 1900 give the age distribution of cotton-mill operatives, hosiery and knitting-mill operatives, paper and pulp mill workers, and cabinetmakers, the aggregate number of such persons being 184,245. This number is exclusive of males under 15 and of males of unknown ages. The statistics show that only 4,342, or 2.4 per cent, had attained to an age of 65 or over, against a normal expected proportion of 4.7. This fact is quite suggestive of conditions unfavorable to health and life in occupations exposing to vegetable fiber dust. The details of the age distribution are given in the following table, by divisional periods of life, together with the corresponding percentage distribution of all occupied males, the data for both groups being derived from the census of 1900.

NUMBER AND PER CENT OF MALES IN EACH AGE GROUP IN **OCCUPATIONS EXPOSED TO VEGETABLE FIBER DUST,** COMPARED WITH NUMBER AND PER CENT IN ALL OCCUPATIONS IN THE UNITED STATES, 1900.

[From report of the Bureau of the Census on Occupations, 1900.]

Age.	Males in occupations exposed to vegetable fiber dust.		All occupied males.	
	Number.	Per cent.	Number.	Per cent.
15 to 24 years	73,209	39.7	5,933,720	26.0
25 to 34 years	47,213	25.6	5,993,847	26.3
35 to 44 years	31,584	17.1	4,704,682	20.6
45 to 54 years	19,115	10.4	3,250,259	14.3
55 to 64 years	8,782	4.8	1,856,181	8.1
65 years or over	4,342	2.4	1,063,856	4.7
Total	184,245	100.0	22,802,545	100.0

According to this analysis, the proportion of persons aged 15 to 34 was 65.3, or nearly two-thirds of the total, against 52.3 expected. At ages 45 or over, the proportion was 17.6 for the group under consideration, against 27.1 for occupied males generally. This favorable age distribution is due to the fact that in the textile industries a considerable proportion of the employees are comparatively young persons, the work being such that no great amount of muscular effort is required.

It is, unfortunately, not possible to present a combined summary of the United States census vital statistics of persons employed in occupations included in this group, since the vital statistics of the census deal only with cabinetmakers and upholsterers. A comparison of the rates for cabinetmakers and upholsterers with the mortality rates of occupied males generally indicates an excessive mortality among cabinetmakers at ages 25 to 44 and at ages 65 or over. The death rate from consumption for cabinetmakers and upholsterers was 3.59, against 2.37 expected, and the death rate from other respiratory diseases was 2.54, against 1.97 expected. The details of the mortality by ages are given in the following table, together with the corresponding death rates for all occupied males, the data for both groups being derived from the census of 1900:

MORTALITY FROM ALL CAUSES AMONG **CABINETMAKERS AND UPHOLSTERERS** IN THE REGISTRATION STATES, COMPARED WITH THAT OF ALL OCCUPIED MALES IN THOSE STATES, 1900, BY AGE GROUPS.

[From report of the Bureau of the Census on Vital Statistics, 1900.]

Age.	Cabinetmakers and upholsterers.			All occupied males.		
	Number employed.	Number of deaths from all causes.	Rate per 1,000 from all causes.	Number employed.	Number of deaths from all causes.	Rate per 1,000 from all causes.
15 to 24 years	4,135	19	4.59	1,259,471	6,486	5.15
25 to 44 years	12,239	128	10.46	2,680,241	23,541	8.78
45 to 64 years	6,825	135	19.78	1,282,259	25,532	19.91
65 years or over	1,496	164	109.63	283,310	27,888	98.44
Total	24,695	446	[a] 18.06	5,505,281	83,447	[b] 15.16

[a] From consumption there were 89 deaths, or a rate of 3.59. From other diseases of the respiratory system there were 63 deaths, or a rate of 2.54.

[b] The rate of mortality from consumption was 2.37; from other diseases of the respiratory system, 1.97.

The occupation mortality statistics of Rhode Island are available for five specific occupations included in this group, and when combined returned 927 deaths from all causes, of which 253 were from consumption and 87 from respiratory diseases other than consumption. The corresponding percentages were 27.3 of deaths from consumption for persons employed in groups with exposure to vegetable fiber dust, against 17.8 for occupied males generally in the State of Rhode Island. The percentage of deaths from other respiratory diseases was 9.4 for the occupations in this group, against 12.5 expected.

The English vital statistics for this group of occupations include textile operatives generally—hosiery workers, lace workers, cordage workers, paper-mill employees, cabinetmakers, and wood turners. When the statistics for these occupations are combined, they exhibit rather high death rates at all ages over 45. The details in tabular form are set forth in the following table:

MORTALITY FROM ALL CAUSES, FROM CONSUMPTION AND FROM OTHER RESPIRATORY DISEASES IN **OCCUPATIONS EXPOSED TO VEGETABLE FIBER DUST,** COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 due to all causes among—		Death rate per 1,000 due to consumption among—		Death rate per 1,000 due to other diseases of the respiratory system.	
	All occupied males.	Occupations exposed to vegetable fiber dust.	All occupied males.	Occupations exposed to vegetable fiber dust.	All occupied males.	Occupations exposed to vegetable fiber dust.
15 to 19 years	2.44	2.59	0.54	0.75	0.24	0.26
20 to 24 years	4.41	4.15	1.55	1.63	.48	.54
25 to 34 years	6.01	5.49	2.03	2.18	.77	.73
35 to 44 years	10.22	9.57	2.74	3.16	1.66	1.46
45 to 54 years	17.73	19.08	3.04	3.80	3.32	3.61
55 to 64 years	31.01	35.47	2.16	2.79	6.54	8.33
65 years or over	88.39	104.00	1.11	1.63	17.77	23.35

The table shows that the mortality from consumption among males with exposure to vegetable fiber dust was excessive at all ages, but particularly so at ages 25 or over. The mortality from respiratory diseases, other than consumption, was about normal at ages 15 to 44, somewhat excessive at ages 45 to 54, and considerably above the normal expected at ages 55 or over.

The industrial insurance mortality statistics are available for eight occupations included in this group, returning in the aggregate 2,460 deaths of males from all causes at ages 15 years or over. Of this number 610, or 24.8 per cent, were from consumption. The deaths from respiratory diseases other than consumption numbered 326, or 13.3 per cent. The expected consumption mortality, on the basis of the mortality of males in the registration area of the United States for the seven-year period 1900 to 1906, was 14.8 per cent, and from other respiratory diseases 11.7 per cent. When the mortality from consumption and from other respiratory diseases is combined, the proportionate percentage of deaths of males in occupations with exposure to vegetable fiber dust was 38.0, against 26.5 per cent expected.

The following table gives the summary statistics in detail for the eight occupations in this group for which the industrial insurance mortality experience has been sufficiently large to warrant their inclusion:

PROPORTIONATE MORTALITY FROM CONSUMPTION IN **OCCUPATIONS EXPOSED TO VEGETABLE FIBER DUST,** 1897 to 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 to 1906, BY AGE GROUPS.

[Figures for occupations exposed to vegetable fiber dust from experience of an industrial insurance company; figures for males in registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths in occupations exposed to vegetable fiber dust, 1897 to 1906, due to—		Per cent of deaths due to consumption in—	
	All causes.	Consumption.	Occupations exposed to vegetable fiber dust.	Males in registration area, 1900 to 1906.
15 to 24 years	244	97	39.8	27.8
25 to 34 years	369	199	53.9	31.3
35 to 44 years	355	143	40.3	23.6
45 to 54 years	404	94	23.3	15.0
55 to 64 years	475	54	11.4	8.1
65 years or over	613	23	3.8	2.7
Total	2,460	[a] 610	[a] 24.8	[b] 14.8

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[a] There were also 326 deaths from other diseases of the respiratory system, or 13.3 per cent of the deaths from all causes.

[b] The per cent of deaths from other diseases of the respiratory system in the registration area was 11.7.

It is evident from the foregoing observations and statistical data relating to a representative number of employments with exposure to vegetable fiber dust that the effects of such exposure are decidedly health injurious. The summary table shows that the mortality from consumption among employees in this group of occupations is very much higher at all ages than would normally be expected.

OCCUPATIONS WITH EXPOSURE TO ANIMAL AND MIXED FIBER DUST.

In the group of occupations exposing to a continuous and considerable inhalation of animal and mixed fiber dusts resulting from necessary industrial processes have been included for the present purpose the following representative employments: Furriers, hatters, silk manufacture, woolen and worsted manufacture, carpet and rug manufacture, shoddy manufacture, rag industry, upholsterers and hair-mattress makers. These occupations are all more or less subject to an excessive death rate from all causes, but in particular to a decided excess in the proportionate mortality from consumption, and in most cases also to a comparatively high degree of frequency in the occurrence of respiratory diseases. The details of labor conditions, as far as they could be conveniently included in the following summary of observations regarding particular trades, appear to fully confirm the opinion that the degree of excess in consumption frequency is intimately related and in almost exact proportion to the degree of exposure to continuous and considerable inhalation of animal and mixed fiber dusts.

FURRIERS AND TAXIDERMISTS.

Fur dressing and dyeing are preliminary manipulations of the fur material for a large variety of subsequent industrial processes, of which the most important is the manufacture of felt hats. While the census of manufactures of 1905 returns the number of wage-earners employed in the dressing of fur at only 1,105,([a]) the total is much larger when persons are included who manipulate fur as a preliminary process in hat manufacture, where the most important operations are pulling, blowing, and forming. All of these are employments exposing considerably and continuously to the inhalation of fine fur dust. The material used in felt hat manufacture is almost exclusively the fur of Belgian hares, which is imported for this purpose in enormous quantities. The preliminary process of fur pulling as carried on in Belgium and England is described in considerable detail by Rose E. Squire, one of His Majesty's inspectors of factories, whose observations and conclusions are of exceptional interest and value. Most of the fur pulling in Belgium is done by women, who work under very trying conditions, and the haze of floating hair, the sickly, disgusting odor of uncleaned skins, and other unfavorable circumstances, attract to this employment only the lowest class of labor. According to Miss Squire, "Fur pullers and openers belong to the poorest class of women. The dirty and repulsive nature of the work, and the low scale of wages, attract none but those who, for one reason or another, can get no other employment." Fortunately, as this observer points out, "Machines are taking the place of hand pulling to a certain extent, but the chief part of the work is done in Belgium, where men do the pulling for a low wage. The manufacturer here finds it cheaper to pay the carriage of British rabbit skins to Belgium and back than to have them pulled in England. Fur pullers are, as a class, irregular workers, and, being paid by the piece, the employer has no hold upon them." While the circumstances of labor in fur pulling and kindred employments are apparently very objectionable and in all probability injurious to health, this conclusion has not been established by such investigations as have been made by Miss Squire and others, and in fact the former observes that "when the workers in any industry are drawn only from that class whose standard of life is the very lowest, when insufficient food and clothing and all the other sad accompaniments of deep poverty have made their mark upon them, it is almost impossible to point to any one physical condition as a result of their occupation. Hoarseness, cough, and a bronchitic condition are common among fur pullers; such are also observed in the old and middle-aged women of the same class who are not fur pullers. One would certainly expect to find evidence among them of suffering caused by inhaling the down present in the air of the workrooms; but, except for occasional complaints that "it stuffs up the chest," most of the workers consider fur pulling a healthy occupation. It may be that the fur being so fine and light is not inhaled; the danger is probably more to be found in swallowing it, and the symptoms of ill health arising from this are, from their nature, not easily discoverable, and must be related by the sufferer; but the poor fur pullers look with suspicion on any inquiry touching their health, fearing that they may be deprived of their work, which, although they say it is not worth the doing, is all they have." ([a])

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[a] Census of Manufactures, 1905, Part I, p. 232.

Aside, however, from the question whether the industry is really injurious to health or not, the sanitary conditions can be materially modified to improve the comfort, and with practical certainty the health of the employees, for, according to Miss Squire, "Much more than has yet been attempted might be done to improve, by specially applied ventilation, the condition of fur-pulling rooms in factories and workshops. The drawing away of the pulled hair from the worker in a downward direction by means of a properly constructed flue under the troughs and an extracting fan would seem to be practicable, and the down could be collected outside in a receptacle for the purpose."

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[a] See article on "Rabbit down," by Miss Squire, in Oliver's Dangerous Trades, p. 724.

The dressing and dyeing of aquatic furs has been described at length in a bulletin of the United States Fish Commission, in which the various processes are illustrated, with special reference to American conditions. It is evident that in most of the processes the risk of dust inhalation is a very considerable one, chiefly, of course, of fine particles of hair, wood, fur (properly so called), and animal down, which is usually a waste product. There is, in addition, a not inconsiderable risk of exposure to the inhalation of other health-injurious kinds of dust, of which arsenic is the most important metallic substance, combining poisonous qualities. From this descriptive account the following is extracted, as emphasizing the more important circumstances which give rise to the production of health-injurious dust and which, no doubt, can be materially modified by improved methods of dust removal at the point of origin:

"If the overhairs are to be removed, that process is next in order, except in the dressing of muskrat skins, when it is usually postponed until after the dressing. In preparing for plucking, the hair side is dried and warmed by artificial heat, the membrane being kept moist in the meantime. Each skin is placed flesh side down on a flat, hardwood beam, similar to that used in breaking except that it is covered with thick, elastic leather. Chalk is first sprinkled over the hair, and then, using a knife similar to that employed in breaking, a workman rubs or works most of the overhairs out of the membrane. Those not removed in this manner are subsequently plucked out with a dull knife of soft metal. With this knife in his right hand and his thumb protected with a rubber cot about 4 inches in length, the picker grasps the hairs between the edge of the knife and his protected thumb and with a quick, jerking motion pulls them out, going over the entire pelt in this manner. The fur seal is quite difficult to unhair, and the process is more complicated."

The process of fur manufacture in felt-hat making is, for the present purpose, the most important one. The number of men employed as fur blowers and cutters in the felt-hat industry is not known with accuracy, but it forms an important branch of the industry. The processes, in their relation to health-injurious circumstances, have been described in some detail in a special report of the Massachusetts state board of health on dangerous occupations, from which the following extract is made:

In the manufacture of derby and felt hats the essential material is fur, and that used for the best product is from cony and allied species. This comes to the factory clipped from the skin and treated with cyanide of mercury. The different kinds of fur are mixed together in large covered machines, in which the coarse hair is separated from the soft, downy fur, which latter is taken to the felt machine. This consists of a revolving copper cone, perforated with numerous small holes, through which the air is drawn by suction apparatus. The cone is inclosed in a barrel-like covering, open at the top, which has a door in the side for the removal of the felt as made. The fine hairs are blown into the upper part of the inclosure, and they are attracted toward the perforated cone by the air currents going thereto. They are then deposited in a thin layer on the outside of the cone, and when the deposit has gone on to a sufficient extent a cloth wrung out in hot water is applied, and the cone and its covering are removed and plunged into hot water for a short time, the heat and moisture causing the individual hairs to become more intimately matted; then the conical layer is pulled off and sent to the shrinking room.

The most recent English mortality statistics of furriers are for the three years ending with 1902, referred to in the Supplement to the Sixty-fifth Annual Report of the Registrar-General in part as follows:

> The numbers comprised in this occupation are too limited to warrant more than general statements concerning them. Except at the age group 20 to 25 years, the death rates are considerably above the standard for all occupied and retired males, and at every age group their mortality very considerably exceeds that of tanners, being more than double as great at some stages of life. In the main working period their comparative mortality figure from all causes is 1,332, or 33 per cent above the standard, and no less than 72 per cent above the corresponding figure for tanners. The mortality from accident and from suicide is less than the standard for all occupied and retired males, and is also less than that for tanners, but from all other causes furriers suffer excessively, the mortality from cancer being three times as great, and that from influenza and phthisis, as well as from nervous and circulatory diseases, being about twice as great as that for tanners.(a)

The recent English statistics for furriers are quite conclusive of the more or less unfavorable effect of this industry on health. In the table which follows a comparison is made of the mortality from all causes among men in this group with that of occupied males generally, and the result is decidedly suggestive of conditions in this trade more or less unfavorable to life and health. The excess in the general death rate of furriers is met with at all ages. The excess in the death rate of furriers at ages 25 to 54 is between 2.29 and 2.69 per 1,000, increasing suddenly to astonishing proportions at ages 55 or over. While the excess at the age period 55 to 64, or 20.27 per 1,000, may be in part the result of comparatively small numbers, the comparison is, nevertheless, decidedly suggestive.

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[a] Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales, p. lxv.

MORTALITY FROM ALL CAUSES AMONG **FURRIERS**, COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 for all occupied males.	Death rate for furriers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	2.44	3.72	+ 1.28	152
20 to 24 years	4.41	4.42	+ .01	100
25 to 34 years	6.01	8.52	+ 2.51	142
35 to 44 years	10.22	12.91	+ 2.69	126
45 to 54 years	17.73	20.02	+ 2.29	113
55 to 64 years	31.01	51.28	+20.27	165
65 years or over	88.39	107.84	+19.45	122

The preceding table is self-explanatory and requires no further comment. A more extended comparison, however, is made in the next table, in which the mortality of furriers from consumption is compared with the normal mortality of occupied males from this disease by divisional periods of life. The comparison shows that the mortality from consumption was excessive at all ages 20 or over, the excess being most marked at ages 35 to 44 and at ages 55 or over.

MORTALITY FROM CONSUMPTION AMONG **FURRIERS**, COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Mortality from consumption.			
	Death rate per 1,000 for all occupied males.	Death rate for furriers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	0.54	....	....	....
20 to 24 years	1.55	1.77	+ .22	114
25 to 34 years	2.03	3.46	+1.43	170
35 to 44 years	2.74	4.74	+2.00	173
45 to 54 years	3.04	3.86	+ .82	127
55 to 64 years	2.16	7.33	+5.17	339
65 years or over	1.11	5.88	+4.77	530

The recorded industrial insurance mortality statistics of furriers and taxidermists include 105 deaths from all causes, of which 34, or 32.4 per cent, were from consumption. Of the mortality of furriers from respiratory diseases other than consumption, 9 were from pneumonia, 5 from bronchitis, and 3 from less frequent respiratory diseases. If the deaths from consumption and from other respiratory diseases are combined, 48.6 per cent of the mortality of furriers was from diseases of the lungs and air passages. The excess in the consumption mortality of furriers is still more clearly brought out in the tabular presentation of the proportionate mortality from this disease by divisional periods of life. While the consumption mortality was excessive at all ages, the excess was most pronounced at 35 to 44, when out of every 100 deaths from all causes 63.3 were from consumption, against a normal expected proportion of 23.6. The numbers are too small for other periods of life to warrant entirely safe conclusions. The analysis of the consumption mortality of furriers in detail is set forth in the table below:

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG **FURRIERS AND TAXIDERMISTS**, 1897, TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for furriers and taxidermists from experience of an industrial insurance company; figures for males in the registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of furriers and taxidermists, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Furriers and taxidermists.	Males in registration area, 1900 to 1906.
15 to 24 years	3	1	33.3	27.8
25 to 34 years	18	7	38.9	31.3
35 to 44 years	30	19	63.3	23.6
45 to 54 years	13	4	30.8	15.0
55 to 64 years	24	2	8.3	8.1
65 years or over	17	1	5.9	2.7
Total	105	34	32.4	14.8

The preceding observations and statistical data regarding the mortality of furriers confirm the conclusion that the degree of consumption frequency in this employment is decidedly excessive and without question directly connected with the health-injurious circumstances of the trade. The excess in the degree of consumption frequency in England and Wales is most marked at advanced years, which would make it probable that the type of the disease assumes in many cases the fibroid form, or that of a distinct occupation disease.

HATTERS.

All who have written on the diseases of occupation have included felt hat manufacture among the trades specifically injurious to health and life. The conditions which give rise to a high death rate and the degree of disease frequency above the normal are primarily due to the continuous and considerable exposure to the inhalation of irritating dust, which is produced during nearly every important process of hat manufacture except the sizing, where steam and vapor, combined with high temperature, increase considerably the liability of the workmen to respiratory diseases. Mercurial poisoning is another serious risk of the industry, but limited to finishers and a few other departments, and, fortunately, less common at the present time than in former years. The felt hat making industry is concentrated in a few States, chiefly New Jersey, New York, and Connecticut. The industry, according to the census of manufactures of 1905, gave employment to 22,047 wage-earners, and of this number 15,432 were males 16 years of age or over.([a]) In addition, however, the manufacture of wool hats gave employment to 1,503 wage-earners, and the manufacture of hat and cap materials to 2,414.

The concentration of the industry in New Jersey early attracted the attention of qualified medical observers, and as far back as 1860 Dr. J. A. Freeman, of Orange, prepared an address on Mercurial Diseases among Hatters for the New Jersey state medical society. In 1878 Dr. L. Dennis, of Newark, prepared a report on Hatting as Affecting the Health of Operatives, at the request of the state board of health, which was published that year in the annual report of the board. In 1886, by request of the same authority, Dr. J. W. Stickler, of Orange, prepared an extended account of the Hygiene of Hat Manufacture and the Diseases of Hatters, including the personal examination of a large number of workmen for evidences of physical impairment in consequence of the industry. The medical investigations were amplified during the years 1889 to 1895 by an elaborate inquiry through the state bureau of labor statistics into the effects of the occupation on the trade life of persons employed in the industry, as part of a general investigation, including many other dangerous and unhealthy employments. The various investigations all confirm the generally accepted view of qualified authorities, that the manufacture of felt hats is attended with more or less health-injurious circumstances, but that some departments of the industry are decidedly more exposed to this risk than others. While the investigations have never been entirely conclusive, in the absence of thoroughly trustworthy statistics of mortality for the more important employments, felt cutters, hat makers, and sizers are apparently the most liable to respiratory and pulmonary diseases and subject to a death rate above the average for persons generally employed in felt hat manufacture. Other employments decidedly injurious to health are pouncing, singeing, steaming, drying, hardening, and mixing, in all of which considerable dust or other health-injurious circumstances increase the liability to respiratory and pulmonary diseases. Finishers, flangers, and curlers are important employments apparently less liable to these diseases, but the degree of difference is, in all probability, not great, since these occupations are often carried on under about the same conditions as other employments previously enumerated, the three occupations being frequently conducted in the same or in adjoining rooms. The improvements which have been introduced into the industry, including the inclosure of dust-producing machinery and the more effectual control of the dust generated during pouncing and finishing at the point of origin, has, no doubt, resulted in a marked improvement during very recent years. Many of the hat factories have been rebuilt and the conditions in the modern factories are decidedly better than in those constructed in former years.

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[a] Census of Manufactures, 1905, Part I, p. 252.

The general vital statistics regarding hatters are very limited but fairly conclusive. According to the vital statistics of 1890 there were enumerated 14,222 hat and cap makers in the registration States of the United States, and of this number 356, or 2.5 per cent, had attained to the age of 65 years or over. The number of deaths from all causes in this group was 277, and of this number 94, or 33.9 per cent, were from consumption. The mortality from all causes for hatters was considerably higher in each age group than the corresponding average for this class of occupations, and at ages 25 to 44, inclusive, the death rate of hat and cap makers was 19.27 per 1,000, or more than twice the average rate in occupations of this class, which was returned as 9.18. The specific death rate from consumption was 6.61 per 1,000, and from respiratory diseases other than consumption, 2.95 per 1,000. The rates were high for all diseases except heart disease and suicide. The death rate from consumption was more than twice the average rate and extremely high in the cities of the registration States only, for which it was returned as 7.8 per 1,000.([a])

The vital statistics of the census of 1900 included the mortality occurring among 12,680 males of known ages 15 or over enumerated as being employed in this group of occupations. The number of deaths from all causes in this group was 228, and the corresponding death rate 18 per 1,000. The death rates per 1,000 of population, by divisional periods of life, were, at ages of 15 to 24, 5.40; at ages 25 to 44, 13.10; at ages 45 to 64 the rate was 32.96; and at ages 65 or over it was 173.8. The death rates of hat and cap makers were generally above the average for the manufacturing and mechanical industries class, being highest from consumption, heart disease, and pneumonia.([a]) For reasons not stated in the census report, the details regarding the mortality in this occupation were less fully reported in connection with the census of 1900 than in connection with that of 1890.

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[a] Vital Statistics, Eleventh Census, Part I, p. 138.

For some years the vital statistics of the United Hatters of North America have been published in semiannual reports, and combining their returns for the period June 1, 1898, to November 30, 1901, there occurred 412 deaths from all causes, and of this number 133, or 32.3 per cent, were from consumption. The number of deaths from respiratory diseases other than consumption was 52, or 12.6 per cent. Combining the deaths from consumption and from other respiratory diseases, there were 185 deaths from diseases of the lungs and air passages, or 44.9 per cent of the mortality from all causes.

The most recent English mortality statistics of hatters are for the three years ending with 1902, referred to in the Supplement to the Sixty-fifth Annual Report of the Registrar-General, in part, as follows:

> The mortality in this occupation shows an excess at every stage of life, the excess being most marked at ages 20 to 25 and 65 and upward. In the main working period the comparative mortality figure is 1,137, or above the standard for all occupied and retired males by 13 per cent. Hatters appear to be specially liable to phthisis, the mortality from that disease exceeding the normal by 50 per cent, and also to other diseases of the respiratory system and to Bright's disease, the mortality from which is above the average by 40 per cent. Suicide is also frequent. On the other hand, the mortality from influenza, nervous diseases, and accident is below the average.([b])

The recent English mortality statistics of hatters are entirely conclusive of the unfavorable effects of this industry on health. In the table which follows a comparison is made of the mortality from all causes among men in this group with that of occupied males generally, and the result is suggestive of conditions in this trade more or less unfavorable to life and health. The excess in the general death rate of hatters is met with at all ages, but the relative and actual excess is most pronounced at ages 45 or over. In this respect the mortality of hatters quite closely resembles the corresponding mortality of furriers and taxidermists.

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[a] Vital Statistics, Twelfth Census, Part I, p. cclxxxiv.

[b] Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales, p. lxii.

MORTALITY FROM ALL CAUSES AMONG **HATTERS**, COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 for all occupied males.	Death rate for hatters.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	2.44	2.90	+ 0.46	119
20 to 24 years	4.41	6.19	+ 1.78	140
25 to 34 years	6.01	6.70	+ .69	111
35 to 44 years	10.22	11.44	+ 1.22	112
45 to 54 years	17.73	19.82	+ 2.09	112
55 to 64 years	31.01	35.97	+ 4.96	116
65 years or over	88.39	103.42	+15.03	117

The preceding table is self-explanatory and requires no further comment. A more extended comparison is made in the next table, in which the mortality of hatters from consumption and other respiratory diseases is compared with the normal mortality of occupied males from these diseases, by divisional periods of life. The comparison shows that the mortality from consumption is excessive at all ages, but the excess is most marked at ages 20 to 54. The table further shows that the mortality of hatters from other respiratory diseases is above the average for occupied males generally at ages 45 or over, by from 1.60 to 6.10 per 1,000. The two tables derived from English sources fully confirm the previous conclusion that the mortality of hatters is excessive when proper comparison is made with the corresponding mortality of occupied males generally, and that this excess is largely because of the high degree of consumption frequency at ages 20 to 54. The table which follows requires no further comment and is otherwise self-explanatory:

MORTALITY FROM CONSUMPTION AND FROM OTHER DISEASES OF THE RESPIRATORY SYSTEM AMONG **HATTERS**, COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Mortality from consumption.				Mortality from other diseases of the respiratory system.			
	Death rate per 1,000 for all occupied males.	Death rate for hatters.			Death rate per 1,000 for all occupied males.	Death rate for hatters.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	0.54	0.61	+0.07	113	0.24	....	....	....
20 to 24 years	1.55	3.47	+1.92	224	.48	0.30	−0.18	63
25 to 34 years	2.03	3.70	+1.67	182	.77	.77	....	100
35 to 44 years	2.74	4.11	+1.37	150	1.66	1.33	− .33	80
45 to 54 years	3.04	4.76	+1.72	157	3.32	4.92	+1.60	148
55 to 64 years	2.16	2.17	+ .01	100	6.54	10.85	+4.31	166
65 years or over	1.11	....	....	....	17.77	23.87	+6.10	134

The recorded industrial insurance mortality statistics of hatters include 832 deaths from all causes, of which 278, or 33.4 per cent, were deaths from consumption. Of the mortality of hatters from respiratory diseases other than consumption, 71 were from pneumonia, 4 from asthma, 12 from bronchitis, and 10 from less frequent respiratory diseases. If the deaths from consumption and from other respiratory diseases are combined, 45.1 per cent of the mortality of hatters was from diseases of the lungs and air passages. The excess in the consumption mortality of hatters is still more clearly brought out in the tabular presentation of the proportionate mortality from this disease by divisional periods of life. While the consumption mortality was excessive at all ages, the excess was most pronounced at ages 25 to 34, when out of every 100 deaths from all causes 55.4 were from consumption, against a normal expected proportion of 31.3. Very few deaths from consumption occurred among hatters at ages 65 or over, but the proportionate mortality was exceptionally high at young ages, having been 53.8 per cent at ages 15 to 24. The analysis of the consumption mortality of hatters in detail is set forth in the following table:

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG **HATTERS**, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for hatters from experience of an industrial insurance company; figures for males in the registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of hatters, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Hatters.	Males in registration area, 1900 to 1906.
15 to 24 years	78	42	53.8	27.8
25 to 34 years	175	97	55.4	31.3
35 to 44 years	185	84	45.4	23.6
45 to 54 years	127	34	26.7	15.0
55 to 64 years	135	20	14.8	8.1
65 years or over	132	1	.8	2.7
Total	832	278	33.4	14.8

The preceding observations and statistical data confirm the conclusion that hatters as a class are subject to an excessive mortality from consumption, but in particular at ages 15 to 64, and this excess, in view of the conditions of labor briefly described, is in a large measure the result of health-injurious circumstances connected with the employment.

SILK MANUFACTURE.

Silk manufacture in the United States is a highly diversified industry, giving employment in 1905 to some 79,601 wage-earners, in 624 manufacturing establishments. Of the number employed 27,037 were adult males, or 34 per cent. ([a]) A large number of women, and children under 16 years of age, are employed in this industry, which offers exceptional opportunities for light and fairly remunerative employment particularly adapted to women and children. While the number of persons employed in the industry has materially increased within recent years, the principal increase has been chiefly in the number of women wage-earners, or to be specific, from about 35,000 in 1900 to a little over 45,000 in 1905. The actual extent of the silk industry, however, is greater than indicated by these statistics, since the manufacture of silk hosiery and silk knit goods is included in the hosiery and knitting industries generally. By products, the industry divides itself into the manufacture of broad silks of many varieties, ribbons, velvets, plushes, tapestry and upholstery goods, machine twists, floss, etc. How far the conditions affecting health vary in the different branches of the industry has not yet been determined with the required accuracy to warrant entirely safe conclusions.

The most important processes in silk manufacture are winding, reeling, spinning, throwing or twisting, warping, weaving, picking, cleansing, and dyeing. On account of the very large variety of goods manufactured and the admixture, according to requirements, of the silk with other textile materials, chiefly cotton and wool, the degree of dust exposure in the different employments varies considerably, so much so that no definite rule can be laid down which would clearly differentiate the health-injurious processes from those which are comparatively innocuous. The hygiene of employment in silk mills was carefully considered by Arlidge, whose opinion was decidedly in favor of silk manufacture as compared with the corresponding conditions affecting health in the manufacture of cotton, linen, or wool. In his opinion the silk industry stands lowest in the list of textile manufactures as a dust-producing and a health-destroying occupation, and is, apart from the general insanitary features surrounding all textile operations, practically devoid of evils originating in the quality of the material and its manipulation, excepting in one department, and that is where waste silk is worked or manipulated for subsequent manufacturing purposes. The processes of winding, twisting, reeling, and spinning, in the opinion of Arlidge, are accompanied by little or no dust where the best silk is in use, and he regards all of these as harmless to health. Since these observations were made a matter of record, however, it is necessary to keep in mind that the admixture of other textile fibers in the manufacture of mixed goods has very considerably increased—so much so that nearly 10,000,000 pounds of yarn other than silk were used by silk mills, according to the census of manufactures of 1905.

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[a] Census of Manufactures, 1905, Part III, p. 161.

Regarding the manufacture of silk waste, Arlidge states that this material is derived either from mills where the best silk is employed, of which it represents, in a certain sense, the refuse; or else from a certain grade of cocoons received from abroad and differing widely in quality. Many of these are so mixed with dirt as to offer, to the uninstructed eye, no semblance of being silk at all, and it is these impure cocoons that give rise, in the preparatory stages of manufacture, to foul smells and dust. Arlidge refers to a report by Redgrave in 1872, to the effect that, "The dressing of waste silk is one of the most nauseous of occupations," which, however, may be rendered comparatively inoffensive and harmless by proper ventilating appliances.

The preparatory processes after the boiling of the cocoon are, according to Arlidge, conducted in what are called the dressing rooms, and it is almost exclusively in these rooms that dust is encountered While many carding machines are inclosed and only give rise to dust at intervals when opened for any purpose, there are horizontally acting machines not admitting of inclosure by their present construction, which do throw off fine dust traceable on surrounding objects and perceptible as a haze in the atmosphere around. In addition to the dressing process, so-called gassing is decidedly injurious to health, since the burned minute particles of silk float in the air, producing the smell of combustion of animal matter to a perceptible degree and likewise a dust visible as a thin haze. The temperature in these rooms is, as a rule, excessive, while the atmosphere is grossly polluted unless artificial ventilation is provided. These observations of Arlidge are in marked contrast to the earlier conclusions of Doctor Greenhow, who conducted an inquiry into the mortality of towns in which the silk industry was concentrated during the early sixties. The mortality from consumption in these towns at that time was extremely high, but during the intervening period vast improvements have taken place and the mortality from consumption has been reduced to the normal of English towns generally. No really qualified investigation, however, has been made into the actual conditions affecting the health of workers in silk mills at the present time, and even Arlidge is forced to the conclusion that—

> A certain amount of asthmatic breathing and bronchitis is, after long employment, set up by the dust of the dressing department and by that of gassing. And judging from the experience of the Macclesfield Infirmary, a considerable number of silk workers break down as age advances with symptoms of fibroid phthisis. Unfortunately there appears to have been no medical research into the pathology of such cases, and no statistical record kept. Further, the high temperature existing in certain workrooms can not be without effect on health. Indeed, the aspect of many of the women, their anæmia and other signs, betray the ills attending their calling.

The very favorable conclusions of Arlidge are also in contrast to the conclusions of Dr. Pierre Givre, who in 1890 published a treatise on tuberculosis among silk workers, chiefly in the silk district of Lyon. According to these researches, among a very considerable number of deaths of silk workers during a long period of years, including both sexes, the mortality from tuberculosis had equaled 35.6 per cent of the mortality from all causes. On contrasting the male with the female workers, the latter exhibited a decidedly higher proportion, while at the same time the deaths occurred at an earlier age. Doctor Givre's opinion was particularly unfavorable to the employments of winders and carders, compared with other branches of the industry. Additional statistical evidence regarding the hygiene of silk manufacture is referred to by Arlidge, who obtained from Dr. Henry Fernie, of Macclesfield, the statistics of 922 persons engaged in the silk trade treated as out-patients at the infirmary. Among this number 25 per cent were cases of either tubercular or respiratory diseases.

For a really conclusive opinion more data are required than thus far have been brought together, with special reference to essential differences in methods of manufacture according to the kind of goods manufactured. As previously stated, the industry lends itself peculiarly to the employment of women and children, and an examination of the age distribution proves that there are comparatively few persons of advanced ages employed in silk manufacture. The age distribution of 49,422 silk workers, 15 years of age or over, with distinction of sex, was as follows:

NUMBER AND PER CENT OF MALE AND OF FEMALE **SILK WORKERS** IN EACH AGE GROUP, 1900.

[From report of the Bureau of the Census on Occupations, 1900.]

Age.	Male silk workers.		Female silk workers.	
	Number.	Per cent.	Number.	Per cent.
15 to 24 years	9,022	44.4	21,884	75.1
25 to 34 years	5,301	26.1	5,082	17.5
35 to 44 years	3,380	16.7	1,519	5.2
45 to 54 years	1,563	7.7	461	1.6
55 to 64 years	785	3.9	127	.4
65 years or over	250	1.2	48	.2
Total	20,301	100.0	29,121	100.0

The table emphasizes the concentration of employments in silk manufacture at the younger ages and the comparative infrequency of employment at ages over 45. Whether the comparatively small number of persons employed in old age is the result of heavy mortality following the early years of employment, or whether it is because of labor requirements more favorable to the employment of young persons, can not be determined at the present time. The table, however, is decidedly suggestive and it probably has some connection with the higher mortality of silk workers than is normal to the general population, although a large number, no doubt, after suffering a temporary impairment, leave the industry for other employments, and they are thus lost sight of in the vital statistics of the trade.

While no conclusive investigation has been made to determine the health conditions in the different branches of the industry, it is probably quite safe to assume that employment in plush and velvet mills is a more dusty occupation than that in mills manufacturing sewing silk or the usual grade of ribbons and broad goods. In the plush mills, employment in the finishing rooms exposes to a considerable amount of dust. Also, in the shearing rooms there is considerable dust, which, however, is reduced by the required humidity of the atmosphere. In the brushing rooms there is considerable dust, and there is probably even more dust at the pegging and so-called tagging machines, which are difficult of exact description. Thus far no thorough investigation has been made, either in this country or abroad, which would warrant final conclusions as to whether the decidedly favorable opinion of Arlidge is warranted by present-day conditions, but as far as it is possible to judge the mortality of silk-mill workers and their liability to tubercular and respiratory diseases is somewhat below the average for persons employed in cotton and woolen mills. The most recent English mortality statistics of silk manufacture are for the three years ending with 1902, referred to in the Supplement to the Sixty-fifth Annual Report of the Registrar-General, in part, as follows:

> The mortality of these workers is below the standard for occupied and retired males at all ages up to the fifty-fifth year, the defect being especially noticeable at the age group 25–35 years. Above the age of 55 years the rates exceed the standard. The comparative mortality figure in the main working period of life is 964, or 4 per cent below the average. These workers are liable to less than one-third of the standard mortality from accident, to one-half of that from influenza, and to two-thirds of that from respiratory diseases, and their mortality from alcoholism and liver disease, as well as from cancer, is also low. On the other hand, they show excessive mortality from phthisis, nervous diseases, Bright's disease, and suicide, especially from the two causes last mentioned.([a])

The recent English mortality statistics for silk workers are quite conclusive of the more or less unfavorable effects of this industry on health as regards the more advanced periods of life. In the table which follows a comparison is made of the mortality from all causes of men in this group with occupied males generally, and the comparison shows that the death rates of silk workers were below the average at ages 15 to 44, slightly above the average at ages 45 to 54, and decidedly so at 55 years or over, when the excess in the death rate was 5 per 1,000 at ages 55 to 64 and 19.16 at 65 or over.

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[a] Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales, p. lxxxvii.

MORTALITY FROM ALL CAUSES AMONG MALE **SILK WORKERS** COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement of the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 for all occupied males.	Death rate for male silk workers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	2.44	2.30	− 0.14	94
20 to 24 years	4.41	3.27	− 1.14	74
25 to 34 years	6.01	4.12	− 1.89	69
35 to 44 years	10.22	8.56	− 1.66	84
45 to 54 years	17.73	17.90	+ .17	101
55 to 64 years	31.01	36.01	+ 5.00	116
65 years or over	88.39	107.55	+19.16	122

The preceding table is self-explanatory and requires no further comment. A more extended comparison is made in the next table, in which the mortality of silk workers from consumption is compared with the normal mortality of occupied males from this disease, by divisional periods of life. The comparison shows that the mortality from consumption is excessive at ages 20 to 34, inclusive, and at ages 45 or over. The exceptions are of minor importance, but the comparison suggests a degree of consumption frequency materially above the average, or by from 0.27 to 1.53 per 1,000. The table which follows requires no further comment:

MORTALITY FROM CONSUMPTION AMONG MALE **SILK WORKERS** COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part 11, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Mortality from consumption.			
	Death rate per 1,000 for all occupied males.	Death rate for male silk workers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	0.54	0.23	−0.31	43
20 to 24 years	1.55	1.82	+ .27	117
25 to 34 years	2.03	2.40	+ .37	118
35 to 44 years	2.74	2.05	− .69	75
45 to 54 years	3.04	3.95	+ .91	130
55 to 64 years	2.16	3.69	+1.53	171
65 years or over	1.11	2.00	+ .89	180

The recorded industrial insurance mortality statistics of silk workers include 295 deaths from all causes, of which 106, or 35.9 per cent, were from consumption. Of the mortality of silk workers from respiratory diseases other than consumption 21 were from pneumonia, 5 from asthma and bronchitis, and 7 from less frequent respiratory diseases. If the deaths from consumption and from other respiratory diseases are combined, 47.1 per cent of the mortality of silk workers was from diseases of the lungs and air passages. The excess in the consumption mortality of silk workers is still more clearly brought out in the tabular presentation of the proportionate mortality from this disease by divisional periods of life. While the consumption mortality was excessive at all ages, the excess was most pronounced at ages 35 to 44, when out of every 100 deaths from all causes 60 were from consumption, against a normal expected proportion of 23.6. The analysis of the consumption mortality of silk-mill workers in detail is set forth in the following table:

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG **SILK WORKERS**, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for silk workers from experience of an industrial insurance company; figures for males in the registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of silk workers, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Silk workers.	Males in registration area, 1900 to 1906.
15 to 24 years	82	28	34.1	27.8
25 to 34 years	61	32	52.5	31.3
35 to 44 years	55	33	60.0	23.6
45 to 54 years	31	7	22.6	15.0
55 to 64 years	37	4	10.8	8.1
65 years or over	29	2	6.9	2.7
Total	295	106	35.9	14.8

The preceding observations and statistical data confirm the conclusion that silk workers as a class are subject to an excessive mortality from consumption, but in particular at ages 15 to 44, and this excess, in view of the conditions of labor briefly described, is in a large measure the result of health-injurious circumstances connected with the employment.

WOOLEN AND WORSTED MANUFACTURE.

The manufacture of woolen and worsted goods has, during recent years, developed into an American industry of very considerable proportions, and in 1905 gave employment to 143,458 wage-earners. Of this number 75,717 were males, 56,749 females, and 10,992 children and young persons under 16 years of age. While an exact division of the industry into woolen and worsted manufacture is somewhat difficult, in approximate numbers there were 72,747 employed in the manufacture of woolen goods, 69,251 in the manufacture of worsted goods, in addition to which there were enumerated 681 wool pullers and 779 wool scourers.([a]) The importance of the woolen industry is gradually declining, while the manufacture of worsted goods is taking its place. Although the processes of manufacture are very much the same as in cotton textiles generally, the worsted industry is a very much more technical process, including some fifty well-defined subdivisions of labor. The most important of these are sorting, scouring, carding, combing, spinning, weaving, dyeing, and finishing. In nearly all of these processes the exposure to animal fiber dust is quite considerable, being somewhat greater in the manufacture of woolen than of worsted goods. The processes of scouring, dyeing, and fulling are comparatively free from dust, but steam, vapor, and dampness increase the disease liability of the workmen in these employments.

Wool sorting is quite a dusty employment, but the risk of so-called "wool-sorter's disease" is limited to the handling of certain grades of foreign wool, chiefly van-mohair, alpaca, East Indian cashmere, and camel's hair, all of which are imported from the Far East. Since these wools are usually imported by way of England they are there, under factory regulations, subjected to a disinfecting process, by which the risk of anthrax is reduced to a minimum. In no branch of the woolen industry is artificial ventilation and dust removal of greater importance than in wool and rag sorting, which, in common with the general risk of dust injury, has the additional risk of transmission of infectious diseases, chiefly anthrax and smallpox. An effective device for removing the dust in wool sorting has been described by Haldane in his lecture on the removal of dust and fumes of factories before the Royal Society of Arts.

The woolen and worsted industries are of such great complexity that only a few of the more important occupations can be considered at this time. Thackrah, in his comments upon the diseases peculiar to persons employed in the manufacture of woolen and worsted goods, observes:

> Wool combers work in apartments which, from the fire employed to heat the combs, are kept at the temperature of about 80°. The fires are made of charcoal. From the evolution of carbonic-acid gas, when the windows are not sufficiently open, the men are occasionally affected with headache. In some of the manufactories an attempt

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[a] Census of Manufactures, 1905, Part III, p. 128.

> has been made to heat the combs by means of steam, but the workmen complain that by this mode the rooms are made hotter and the combs colder; in other words that the increase of temperature is more diffused. A light dust arises from the wool, or rather perhaps from the soap retained by the wool after washing. It annoys the air tube and obliges some persons to leave the employ. The men, however, whom we found in the rooms appeared quite healthy, and we were informed that out of 100 individuals only 2 or 3 were absent from illness. * * * The heat of the apartments does not appear to shorten life. We have repeatedly seen at work men from 60 to 70 years of age.

The same authority says with reference to worsted spinners that—

> Spinners of worsted, chiefly young persons, are exposed to considerable heat in rooms traversed by steam pipes and often deficient in ventilation. The thermometer, in November, we have found in the spinning rooms at 65° and 70°, and in the warping rooms, where steam pipes are not introduced, 58°, while in the open air it was 48°. In summer, of course, the temperature, particularly of the spinning rooms, is considerably higher. The rooms in most mills, though spacious, are too low. The windows are about the middle of the walls and no apertures are made above them for the admission of air. The labor is light and the posture varied. * * * The operatives have generally the appearance of health. Many, however, particularly at the commencement of the employ, suffer from headache and sickness, the result, I conceive, of the want of ventilation rather than the temperature of the rooms. Some can not bear the employ. The mills are generally in the country or at the outskirts of the town.

At the time, however, when Thackrah reported his observations the worsted industry had developed to only very small proportions, chiefly the manufacture of worsted handkerchiefs, fancy goods, and worsted stockings. The weavers employed in the manufacture of these goods were, in the opinion of Thackrah, subjected to some dust, which affected the respiration and rendered the employment less healthful than the corresponding occupation in cotton manufacture. This opinion has not been sustained by subsequent investigation, which would appear to prove conclusively that the manufacture of woolen and worsted goods is less injurious than employments in the manufacture of cotton goods.

During recent years the conditions of labor in the woolen and worsted industries have undergone a material improvement, largely as the result of the concentration of the industry in the elimination of many small factories not built in conformity to modern sanitary requirements as to air space, light, and ventilation. While important improvements have been made, it is still rare, however, to find an effective system of artificial dust removal, chiefly in the processes generating the largest quantities of dust—that is, the carding and combing branches of the industry. The amount of fly resulting from the various operations is considerable in both woolen and worsted manufacture and continuous cleaning is necessary, and this is practically all done by means of the ordinary sweeping process, much of which results in dust disturbance rather than in dust removal.

The woolen and worsted industries were very carefully considered by Arlidge in his treatise on the diseases of occupation. He calls attention to the fact that most of the health-injurious processes are those which have to do with the preparatory stages, and he describes these processes in their relation to health, in part, as follows:

> In the first place, the bales have to be opened, and their contents being heaped upon large tables have to be sorted in order to separate their different qualities. Along with more or less dirt removed with the fleeces, the wool holds a considerable quantity of greasy matter. From this last it has to be freed by careful and repeated washings in alkaline fluids and by specially constructed machines. It has, in the next place, to be subjected to "willying" (winnowing), "scribbling," and "carding machines" to remove every portion of dirt and to deliver it, as in the cotton manufacture, in the form of a "sliver" of fine fibers collected in a loose rope-like form. In the preliminary combing processes considerable dust is thrown off, but by the use of inclosed machines and of fans to withdraw it as fast as it is generated little escapes into the apartment to annoy or to injure. We owe it to the ingenuity of modern engineers that these preliminary operations have well-nigh ceased to be unhealthy.

Arlidge, as the result of his investigations, held that the dust from wool was more innocuous than that of cotton, and very much more so than the dust of flax, because of the inherent structure of the wool fiber and the fact that its animal origin makes it less irritating and less foreign to living animal tissue. Moreover, he held that when the woolen fibers reached the spinning frames they had to be lubricated with oil, which materially reduced the amount of dust generated during the subsequent manipulation. This conclusion, however, is subject to material modification in many mills, where the evidence of a considerable amount of dust being generated during the spinning process is readily observed by the amount of dust under and on the machinery and present in the atmosphere.

With special reference to worsted spinning and weaving, Arlidge observed that—

> Other advantages attending the worsted spinning are that it is done dry and does not need the same degree of moist heat required in the other textile trades. Further, in the weaving of worsted a far lower and less humid temperature is called for than in the case of cotton weaving; while, what is of still greater moment, clay sizing and its emitted dust have no place.

Arlidge sums up his general conclusions regarding the health of persons employed in the woolen and worsted industry as follows:

> The general conclusion respecting the worsted manufacture is that it is a healthy occupation. The artisans look less anæmic and sallow than cotton operatives, while their social and domestic position

appears more favorable. They likewise suffer less with respiratory diseases and consumption; but the proportion in which these prevail is in some degree regulated by the quality of wool used, that from Australia and the Cape being more dusty than English and therefore more provocative of bronchial irritation. Doctor Greenhow could not find that chest diseases and the mortality therefrom occurred in a higher ratio among the woolen workers of Bradford than with the general population.

Other writers on occupation diseases have given equally extended consideration to the industry, but, on the whole, the conclusions coincide with those of Arlidge, that employment in woolen and worsted manufacture, with the resulting exposure to animal fiber dust, is less dangerous to health than the corresponding employment in the manufacture of cotton and other vegetable fiber textiles.

Dr. B. W. Richardson held that the dust or fly of wool appeared to produce no really deleterious effects on the lungs, and that, in fact, the mortality of the workers in wool seemed to warrant the opinion that they were favorably exempted from disease, probably because the soft, oily dust of the wool protected the bronchial surfaces from irritation rather than that it irritated them. Tatham, writing with a better knowledge of the mortality statistics of the trade, confirms this opinion in his discussion of dust-producing occupations in Oliver's Dangerous Trades, from which the following is quoted:

> Wool workers suffer much less severely from their occupation than do cotton operatives. In the weaving of woolen materials a lower and drier temperature is required than in the case of cotton weaving, and the mischief caused by "sizing" with china clay and other irritants has no place in woolen manufacture. Nevertheless, in certain of the processes, especially where inferior foreign wools are manufactured, a good deal of dust is disengaged, and this produces its ill effect on the lungs of the workers. It is also in connection with dirty or blood-stained foreign wools that the majority of cases of anthrax or wool sorters' disease have been observed from time to time which have been the subject of inquiry in past years by the medical department of the local government board.
>
> It is worthy of notice that wool sorters are even more careless as regards exposure to cold and drafts than are even cotton workers, and their mortality from rheumatic fever is much higher, being double that experienced by agriculturists as a class. Wool workers have a comparative mortality figure from all causes which is somewhat above the average for occupied males generally, but is below that of other textile trades. Workers in wool appear to be remarkably free from intemperance, their mortality figure being less than one-fourth of the average. From diseases of the digestive system other than the liver wool workers die half as fast again as do occupied males generally, while from diseases of the nervous, respiratory, and urinary systems, as well as from cancer, the mortality of these workers is from 10 to 22 per cent in excess of that standard.

The Rhode Island occupation mortality statistics return specifically only wool sorters. During the ten years 1897 to 1906 there were 37 deaths from all causes recorded in Rhode Island under the title of wool sorter. Of this number 5, or 13.5 per cent, were from consumption, and 5, or 13.5 per cent, were from respiratory diseases other than consumption. The combined mortality from diseases of the lungs and air passages was 10, or 27 per cent, against 30.3 per cent expected on the basis of the mortality of all occupied males in Rhode Island. The numbers are too small to warrant a final conclusion, but the facts are presented to make the analysis complete.

The most recent English mortality statistics of woolen and worsted manufacture are for the three years ending with 1902, referred to in the Supplement to the Sixty-fifth Annual Report of the Registrar-General, in part, as follows:

> The mortality among these operatives exceeds the standard for occupied and retired males at ages 20 to 25, and over 55 years, but is below that standard at other ages. In the main working period of life the comparative mortality figure for wool workers is 984, or less than the standard figure by only 2 per cent. The mortality from alcoholism and liver disease is less than three-fourths and that from accident is less than half the standard. The mortality from cancer, phthisis, respiratory diseases, and suicide is also in each case below the average. On the other hand, the mortality from nervous and circulatory diseases slightly exceeds, and that from diabetes mellitus and from Bright's disease considerably exceeds the standard.(a)

The recent English mortality statistics for persons engaged in woolen and worsted manufacture are fairly conclusive of the somewhat unfavorable effects of this industry on health, and decidedly so as regards the more advanced periods of life. In the table which follows a comparison is made of the mortality from all causes among men in this group with that of occupied males generally, and the result is suggestive of conditions in this trade more or less unfavorable to life and health. An excess in the general death rate of woolen and worsted workers is met with at ages 20 to 24, but at all other ages below 55 the mortality is below the normal, while at ages 55 to 64 the excess in the general death rate of woolen and worsted workers is 6.09 per 1,000, and at ages 65 or over it is 40.53 per 1,000.

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[a] Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales, p. lxxxvii.

MORTALITY FROM ALL CAUSES AMONG MALE **WOOLEN AND WORSTED WORKERS**, COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part 11, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000, for all occupied males.	Death rate for male woolen and worsted workers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	2.44	2.19	− 0.25	90
20 to 24 years	4.41	5.03	+ .62	114
25 to 34 years	6.01	5.18	− .83	86
35 to 44 years	10.22	8.90	− 1.32	87
45 to 54 years	17.73	17.14	− .59	97
55 to 64 years	31.01	37.10	+ 6.09	120
65 years or over	88.39	128.92	+40.53	146

The preceding table is self-explanatory and requires no further comment. A more extended comparison is made in the next table, in which the mortality of woolen and worsted workers from consumption and other respiratory diseases is compared with the normal mortality of occupied males from these diseases, by divisional periods of life. The comparison shows that the mortality from consumption was excessive at ages 15 to 24 and at 55 years or over. The table further shows that the mortality from other respiratory diseases was excessive at ages 15 to 19 and at 65 years or over. The two tables, derived from English experience, would seem to warrant the conclusion that the woolen and worsted industry as such is not decidedly injurious to health. The data, however, are subject to a word of caution, in that the woolen and worsted industry includes many employments which permit of a comparatively easy transfer to other industries and occupations, so it is quite possible that a fair proportion of those impaired because of continuous exposure to animal and fiber dust, leave the employment and seek more congenial and healthful occupations in other branches of industry. This view is in part susceptible of statistical proof by the comparative mortality data of occupied and of occupied and retired males in the woolen industry of England and Wales, which for the first time were tabulated for the three years ending with 1902. The excess in the death rate of occupied and retired males employed in this industry over the occupied only was very slight at ages under 35, but 0.32 per 1,000 at ages 35 to 44, 0.86 at 45 to 54, 3.83 at 55 to 64, and 18.19 at 65 years or over.

MORTALITY FROM CONSUMPTION AND FROM OTHER DISEASES OF THE RESPIRATORY SYSTEM AMONG **WOOLEN AND WORSTED WORKERS**, COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Mortality from consumption.				Mortality from other diseases of the respiratory system.			
	Death rate per 1,000 for all occupied males.	Death rate for woolen and worsted workers.			Death rate per 1,000 for all occupied males.	Death rate for woolen and worsted workers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years.....	0.54	0.69	+0.15	128	0.24	0.31	+0.07	129
20 to 24 years.....	1.55	2.38	+ .83	154	.48	.23	− .25	48
25 to 34 years.....	2.03	1.81	− .22	89	.77	.75	− .02	97
35 to 44 years.....	2.74	2.25	− .49	82	1.66	1.45	− .21	87
45 to 54 years.....	3.04	2.84	− .20	93	3.32	3.08	− .24	93
55 to 64 years.....	2.16	2.27	+ .11	105	6.54	6.46	− .08	99
65 years or over..	1.11	1.86	+ .75	168	17.77	25.44	+7.67	143

The recorded industrial insurance mortality statistics of woolen and worsted mill workers include 106 deaths, of which 26, or 24.5 per cent, were from consumption. Of the mortality of woolen-mill workers from respiratory diseases other than consumption, 8 were from pneumonia, 7 from asthma and bronchitis, and 2 from less frequent respiratory diseases. If the deaths from consumption and from other respiratory diseases are combined, it is found that 40.5 per cent of the mortality of woolen-mill workers was from diseases of the lungs and air passages. The excess in the consumption mortality of woolen-mill workers is still more clearly brought out in the tabular presentation of the proportionate mortality from this disease by divisional periods of life. While the consumption mortality was excessive at all ages, the excess was most pronounced at ages 25 to 34, when out of every 100 deaths from all causes 43.8 were from consumption, against a normal expected proportion of 31.3. The analysis of the consumption mortality of woolen-mill workers in detail is set forth in the following table:

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG **WOOLEN AND WORSTED WORKERS**, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for woolen and worsted workers from experience of an industrial insurance company; figures for males in the registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of woolen and worsted workers, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Woolen and worsted workers.	Males in registration area, 1900 to 1906.
15 to 24 years	20	7	35.0	27.8
25 to 34 years	16	7	43.8	31.3
35 to 44 years	14	5	35.7	23.6
45 to 54 years	19	4	21.1	15.0
55 to 64 years	24	3	12.5	8.1
65 years or over	13	....	....	2.7
Total	106	26	24.5	14.8

The preceding observations and statistical data confirm the conclusion that woolen and worsted workers in the United States as a class are subject to a high mortality from consumption, but in particular at ages 15 to 44, and this excess, in view of the conditions of labor briefly described, is in a large measure the result of health-injurious circumstances connected with the employment.

CARPET AND RUG MANUFACTURE.

Carpet and rug manufacture may properly be considered a branch of the woolen and worsted industry, but it is only the weaving and finishing processes which require special consideration. The grade of yarn used probably has some bearing upon the quantity of dust generated during the process of manufacture, but it is in the so-called shearing and brushing that atmospheric pollution occurs in excess of similar conditions in woolen and worsted mills. The report of the Massachusetts state board of health on dangerous trades contains a brief reference to the sanitary aspects of the industry, from which the following is quoted:

> The operation of carpet weaving is accompanied by much dust, and requires constant attention and keen watching for flaws and "skips" in the weaving. After a carpet or rug is woven it is inspected, sheared, and brushed. The shearing machines cut off all bits of fiber and other irregularities, and in so doing create considerable dust, much of which is coarse and heavy and does not long remain suspended in the air.
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> Five carpet factories visited employ about 6,000 persons, about 10 per cent of whom are between the ages of 14 and 16. The largest of these shows some departments in which poor light, excessive heat, moisture, and dust constitute the objectionable conditions. One large,

fairly well lighted room, 220 by 120 by 16 feet, and occupied by 33 persons, has so much fine cotton dust and fiber in the air that it is with difficulty one can see across it. This dust is very irritating to the nose and throat.

Some of the rooms are poorly lighted, some are overheated, and some are badly ventilated; and one large basement room, 285 by 60 by 13 feet, occupied by 150 women and girls winding yarns on bobbins, combines all three of these objectionable conditions.

The wool-picking room is well lighted, but the air is heavy with wool fiber, and is at the same time excessively hot. One large dusting machine is equipped with a fan and exhaust dust pipe which never have been used; indeed, there is no shafting to run the fan. The machine has been in use upward of five years, and the person who operates it has worn a handkerchief over nose and mouth ever since it was started. The work is exceedingly dusty and dirty.

The weaving rooms of the next largest of the five factories are large and well lighted, but the air contains a noticeable amount of dust. Most of the departments of this mill show commendable conditions.

In the third, many of the children between 14 and 16 are very small and poorly developed for their age, and are far too poorly developed to be allowed to work ten hours and twenty minutes for five days in the week. In many rooms the windows are too far apart, and the light is barely sufficient even in good clear weather. The older weavers complain of failing eyesight, due to working with poor light.

One of the mills of this establishment, although comparatively new, is poorly lighted in the picking, carding, winding, drawing, and roving rooms, but otherwise the conditions are good. In four of the weave rooms the ventilation is very inadequate, the light is poor, and the air is very dusty.

The fourth establishment in order is, in the main, poorly lighted and inadequately ventilated, and the weave rooms are very dusty. In four rooms in which yarns are dressed the steam boxes are so loosely constructed that much steam escapes and causes extreme heat and moisture. About one-tenth of the employees in this establishment look sickly.

The smallest factory of all, one which employs ordinarily 500 persons, has good light, adequate ventilation, and commendable weave rooms. The employees appear to be in good health.

The hygiene of carpet manufacture has not attracted much attention, probably because of the fact that most of the processes are practically identical with the corresponding processes in woolen and worsted manufacture. The occupation classification in the carpet industry, however, includes a number of employments peculiar to the trade, of which mention may be made of art-square weavers, cutters of chenille cloth, fringe knotters, jute binders, plush weavers, shearers, steamers, willowers, and wire sharpeners. Of these occupations, employment at the willowing machines is probably the most dusty, since it is here that the wool fibers are torn apart and the dust and dirt removed. It is also probable that conditions in carpet-weaving rooms are less favorable on account of the coarser grade of yarn used and the material differences in loom construction. The weaving process itself is also quite different from the corresponding process of weaving in woolen and cotton textiles, and as far as it is possible to judge, the amount of dust generated during the weaving processes is greater in carpet and rug mills than in the corresponding processes of other branches of the textile industry. No qualified investigation, however, has been made which would warrant a final conclusion, nor has it been determined whether the amount of dust in the manufacture varies according to the varieties of carpets made, of which the most important are Wilton, Axminster, Kidderminster or ingrain, tapestry Brussels, and Venetian. The manufacture of matting is a separate industry, with exposure to vegetable fiber and mineral dusts, while in the manufacture of door mats the principal exposure is to mixed fiber dust. Arlidge sums up his conclusions regarding the hygiene of carpet making, briefly, as follows:

> The wool used for carpet making is of coarse and short fiber; it is formed into a yarn, which is next wound on bobbins by child labor in readiness for the weavers' looms. Hand-loom weaving has been, for the most part, supplanted by the power loom, with the advantage of materially lessening the labor of the weavers. The manufacture of carpets is attended with considerable dust of a mixed character of wool and hemp, but no data are within reach to furnish information as to the extent in which it operates as a cause of disease.

The mortality of males employed in carpet manufacture was reported upon in the Supplement to the Fifty-fifth Annual Report of the Registrar-General of England and Wales. The number of men employed was comparatively small, having been only 8,532 at ages 15 or over, hardly warranting definite conclusions in view of the short period of three years for which the mortality data were returned. In general terms it was held that the death rates of carpet makers at the various age groups compared favorably not only with those of other textile workers but also with those of other occupied males. The comparative mortality was 873, which is 8 per cent below the standard. Among the causes of death of numerical importance consumption was 22 per cent in excess of the normal, and diseases of the respiratory system other than consumption were 11 per cent in excess. The mortality of carpet makers from diseases of the nervous, circulatory, digestive, and urinary systems appears to be below the average.

One fact which requires to be taken into consideration, however, is that in carpet weaving considerable physical strength is required, which accounts for the comparatively small proportion of women weavers. This, at least, is true of the weaving of Brussels carpet and probably applies to other grades. It is the opinion of those who are thoroughly familiar with the industry that men of exceptional physique are required, and naturally among such a class the death rate should be low unless very abnormally increased by special causes. The most recent English mortality statistics of carpet and rug manufacture are for the three years ending with 1902, referred to in the Supplement to the Sixty-fifth Annual Report of the Registrar-General in part as follows:

> Here again the workers are too few in number to justify more than general examination. It appears that the mortality in this industry is below the standard for occupied and retired males at ages 25–45 years, but above it at all other ages. In the main working time of life the comparative mortality figure is 1,044, or 4 per cent above the standard. These workers show a fatality in excess of the average from cancer and from diseases of the nervous and circulatory systems, but in defect of the average from influenza, alcoholism, and liver disease, as well as from accident and suicide.[a]

The recent English mortality statistics of carpet and rug makers are quite conclusive of the more or less unfavorable effect of this industry on health. In the table which follows a comparison is made of the mortality from all causes among men in this group with that of occupied males generally, and the result is decidedly suggestive of conditions in this trade more or less unfavorable to health and life, but in particular at very advanced ages, when at 65 years or over the excess in the death rate of carpet and rug makers was 28.38 per 1,000.

MORTALITY FROM ALL CAUSES AMONG MALE **CARPET AND RUG MAKERS**, COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 for all occupied males.	Death rate of male carpet and rug workers.		
		Rate per 1,000.	Greater (+) or less (—) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	2.44	2.89	+ 0.45	118
20 to 24 years	4.41	5.19	+ .78	118
25 to 34 years	6.01	5.86	— .15	98
35 to 44 years	10.22	9.43	— .79	92
45 to 54 years	17.73	18.30	+ .57	103
55 to 64 years	31.01	33.94	+ 2.93	109
65 years or over	88.39	116.77	+28.38	132

The preceding table is self-explanatory and requires no further comment. A more extended comparison is made in the next table, in which the mortality of carpet and rug makers from consumption is compared with the normal mortality of occupied males from this disease, by divisional periods of life. The comparison shows that the mortality from consumption was above the average at ages 15 to 24, 35 to 44, and 55 to 64. Making allowance for the rather small numbers from which this table is derived, it is probably safe to assume that if the numerical basis were larger it would more conclusively indicate a comparatively high degree of consumption frequency among men in this employment, at least throughout the active working period of life.

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[a] Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales, p. xc.

MORTALITY FROM CONSUMPTION AMONG MALE **CARPET AND RUG MAKERS**, COMPARED WITH THAT OF ALL OCCUPIED MALES IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Mortality from consumption.			
	Death rate per 1,000 for all occupied males.	Death rate of male carpet and rug makers.		
		Rate for 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied. males.
15 to 19 years	0.54	0.64	+0.10	119
20 to 24 years	1.55	2.59	+1.04	167
25 to 34 years	2.03	1.41	− .62	69
35 to 44 years	2.74	3.14	+ .40	115
45 to 54 years	3.04	2.94	− .10	97
55 to 64 years	2.16	2.42	+ .26	112
65 years or over	1.11	1.00	− .11	90

The recorded industrial insurance mortality statistics of carpet and rug makers include 155 deaths from all causes, of which 37, or 23.9 per cent, were from consumption. Of the mortality of carpet and rug makers from respiratory diseases other than consumption, 16 were from pneumonia, 6 from asthma and bronchitis, and 4 from less frequent respiratory diseases. If the deaths from consumption and from other respiratory diseases are combined, it is found that 40.6 per cent of the mortality of carpet and rug makers was from diseases of the lungs and air passages. The excess in the consumption mortality of carpet and rug makers is still more clearly brought out in the tabular presentation of the proportionate mortality from this disease by divisional periods of life. While the consumption mortality was excessive at all ages, the excess was most pronounced at 15 to 24, when out of every 100 deaths from all causes, 52.9 were from consumption, against a normal expected proportion of 27.8. The analysis of the consumption mortality of carpet and rug makers in detail is set forth in the following table:

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG **CARPET AND RUG MAKERS**, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for carpet and rug makers from experience of an industrial insurance company; figures for males in the registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of carpet and rug makers, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Carpet and rug makers.	Males in registration area, 1900 to 1906.
15 to 24 years	17	9	52.9	27.8
25 to 34 years	22	10	45.5	31.3
35 to 44 years	17	6	35.3	23.6
45 to 54 years	24	5	20.8	15.0
55 to 64 years	34	4	11.8	8.1
65 years or over	41	3	7.3	2.7
Total	155	37	23.9	14.8

The preceding observations and statistical data confirm the conclusion that carpet and rug makers in the United States are as a class subject to an excessive mortality from consumption, but in particular at ages 15 to 44, and this excess, in view of the conditions of labor briefly described, is in a large measure the result of health-injurious circumstances connected with the employment.

SHODDY MANUFACTURE.

Shoddy manufacture is an important branch of the woolen and worsted industry, although the number of wage-earners employed is comparatively small. In 1905 there were 97 establishments manufacturing shoddy in the United States, employing 2,089 wage-earners, compared with 1,926 in 1900, an increase of 8.5 per cent during the intervening quinquennial period. Of the number of persons employed, 1,625 were adult males, 458 were women, and 6 were children under 16 years of age.([a]) The materials used in shoddy manufacture are chiefly woolen and worsted rags, including tailors' clippings and wool extract, which is the wool fiber derived from rags, freed by a process known as carbonizing of the vegetable material with which it may have been intermixed, such as cotton and other vegetable fiber. Most of the shoddy made at the present time is all wool, and it is an error to assume that all shoddy goods are really undesirable for wearing purposes, since a very considerable proportion is cloth made wholly of wool but produced at a price which affords to poor people a satisfactory article of wear. It is also an error to assume that through shoddy loathsome diseases are conveyed to the wearer, except possibly in exceedingly rare instances, since the process of shoddy manufacture i such as to insure absolute cleanliness and the destruction of all active germs whether innocuous or pathogenic. This statement of facts is derived in part from the special census report on textiles, in which the shoddy industry is considered at some length. It is pointed out in that report that new wool or animal hair is always the basis of the yarn intermixed with a certain amount of shoddy, the fiber of which is too short to be carded and spun alone. While the completed cloth is not as durable as the cloth made from new wool, it is by no means lacking in wearing quality, as is commonly supposed, for as pointed out in the census report just referred to, shoddy in fact is one of the most useful of modern by-products in manufacture, in which the utilization of waste is an important item of economy. "Shoddy is not," in the words of the report, "woolen rags ground to powder, but rags that are picked, leaving a good staple suitable for spinning. Some of the most substantial of goods that are made, doing serviceable work for a number of years, contain a portion of shoddy mixed with wool." The process of converting the rags into wool fiber suitable for carding consists of a picking process in a machine known as a "shoddy-picker," and this constitutes a very dusty process which no doubt gives rise to health-injurious circumstances, to which, in part, reference has been made in the discussion of the hygiene of the paper industry, to which subsequent reference will be made in discussing rag collecting and rag sorting as a separate occupation. An essential difference, however, has to be kept in mind, and that is that only woolen and worsted rags are used in shoddy manufacture, while cotton and linen rags are used in paper manufacture.

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[a] Census of Manufactures, 1905, Part III, p. 116.

In discussing the whole subject of rags and their products in relation to health, Mr. John A. E. Stuart, medical officer of health, Batley, Yorkshire, refers to the manufacture of shoddy, in part, as follows:

> The dust which rises from rag machines consists of particles of wool and also of filth adherent to the various kinds of rags. It is highly irritating to all the respiratory passages, especially in those who are novices at the trade, but older hands become inured to it and tolerate it well. A train of symptoms is developed, called "shoddy fever." It is accompanied by high fever, with nasal catarrh and frontal headache, and a certain amount of bronchial catarrh. It is ushered in by shivering, malaise, and general muscular pain. It is almost indistinguishable from epidemic influenza, and if treated on similar lines recovery is soon secured. The only difference is that the catarrhal symptoms are the result of local irritation, and, consequently, when that is removed, the febrile condition soon subsides. Shoddy fever is easily induced in persons who have been out of the mill for a few weeks and return to work, in persons suffering from general catarrh, or in habitual drunkards.

A distinction is made by English writers between shoddy and mungo, the former being made from soft rags and the latter from cloth rags, while the commoner kind of flocks, so called, are manufactured from a variety of raw materials, including the refuse of the shoddy trade, while the superior qualities are manufactured from the better grade of raw material. The lowest class of flocks is made from old carpets, with a backing of hemp or other vegetable fiber, and the product is used for stuffing beds and articles of furniture. The preliminary methods of manufacture of shoddy, mungo, and flocks are practically the same. "Flock fever" may here be referred to. This is met with in flock manufacture, and upholsterers working with flocks are occasionally sufferers from the dust. According to Stuart, workers in shoddy mills suffer from bronchitis and emphysema of the lungs, but those who do so are the older men, who began to work before so much oil was used with the rags as is at present the case, at least in English shoddy factories. The process is known as carbonizing, which is applied to rags which have a certain amount of cotton in them, and is stated to be occasionally the cause of bronchitis and emphysema, but men working in carbonizing mills state that it is quite exceptional for men to be off on account of illness.([a])

Arlidge has described the process of shoddy manufacture in more detail than any other writer on the subject, and his observations and conclusions are quoted, in part, as follows:

> The first operation consists in a more careful separation of the woolen from cotton and linen rags, as received from the rag dealers. It is one attended by the evolution of much dirty dust obnoxious to the respiratory organs, and now and then charged with animal poisons of a contagious or infectious nature. As an entirely unskilled operation, bringing small reward, sorting is undertaken by a lower class of female workers, indifferently careful of their own sanitary well-being.
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> The sorted rags are next torn up by a machine called a "devil," into small fragments. This process is necessarily a most dusty and otherwise objectionable one, but as it is done in an inclosed machine, comparatively little dust escapes into the surrounding air. The heavier particles fall to the bottom, whilst the lighter are driven by a strong blast of air, blown through the machine by a fan, along a capacious tube or conduit, and disposed of in an outside place. * * *
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> A further tearing apart, scribbling, or grinding is accomplished by a rough carding process, whereby a disintegrated mass of finely broken up wool fibers is obtained. After the free addition of vegetable oil to this material, it is transferred to "willying" and roving machines, from which it emerges as a filmy sheet, which is immediately, by a semirotary action of the machine, converted into a "shiver," ready for future spinning and weaving.
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> The addition of the oil to the carded material has the great sanitary gain of obviating the emission of dust in the subsequent operations. Whilst in the disintegrated shape, additions of new wool and

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[a] For a technical description of the process of carbonizing and the manufacture of shoddy, see Principles of Woolen Spinning, by Howard Priestman, p. 46 et seq. New York, 1908.

> of cotton are made. The wool used for cloth making is what is known as short wool, and is not suitable to the worsted spinners.
>
> After the cloth is woven it passes through manifold other operations. Those first pursued are intended to remove defects in the tissue, and to fit it for dyeing and pressing. Others that follow are fulling (beating the cloth by heavy weights), dressing, raising the pile by teazles fixed in revolving frames, drying in hot chambers, shearing or cutting down the pile, and some finishing processes, such as subjecting the cloth to steam in order to remove the gloss consequent on previous pressure between steam rollers.
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> The only sanitary conditions to be found in these sundry proceedings requiring notice are the dust given off when the pile is raised in dry cloth; the elevated temperature of the drying room, reaching as it does 130° and upward, and the steam generated in the last operation described. Shearing is a comparatively leisurely proceeding, and the fine shavings cut off have a cohesive nature which opposes their diffusion in the form of dust. In the other departments enumerated, the work is performed by adult men, who are also few in number.

These observations are in part not quite applicable to American conditions, but no descriptive account of shoddy manufacture in this country has been made a matter of record with special reference to the hygienic circumstances of the occupation. In a large measure, of course, the processes subsequent to the preparation of the material for spinning and weaving are identical with those of woolen and worsted manufacture, but it is quite probable that the amount of dust generated during these processes is somewhat larger in shoddy manufacture. The investigations of Arlidge do not confirm similar inquiries as to the frequency of shoddy fever at the present time, but it is quite probable that there are sufficient variations in the methods of manufacturing, especially in the grades of rags handled, which may easily account for the absence of shoddy fever in one locality and its occurrence in another.

These brief observations are concluded by an extract on the manufacture of shoddy, included in a report on dangerous occupations by the state board of health of Massachusetts, published in 1907:

> Shoddy is made from woolen rags, which come ordinarily to the mill in the form of bales. The first process, after the bales are opened, is that of sorting, which is done by women, who pick out all cotton rags, silk mixtures, buttons, and other foreign matters. The selected rags are treated in a large vat with dilute sulphuric acid, which attacks and destroys all cotton fibers which may be present, and then they are removed from the bath and allowed to drain. Next they are spread on racks over steam pipes, and dried at a temperature of about 100° F. in a confined space, which, before the dried rags are removed each day, is thoroughly ventilated by opening the windows and operating a blower, so that the men who do the work may not be exposed to the fumes. The rags are next washed, and then are picked apart by machinery. The product is a pure wool of short fiber and

very clean, which is sold either dyed or undyed. Two establishments of this class were examined, one of which is poorly lighted, inadequately ventilated, dusty, and ill kept; the other is light, clean, and well ventilated. Some of the women employed appeared to be in poor physical condition.

There are no official vital statistics of this occupation, but it is evident that while the circumstances of the employment are apparently decidedly objectionable, and while the dust generated during certain processes is considerable, the evidence that the employment itself is distinctly injurious to health is not a matter of trustworthy record, nor is it even conclusively evident that there is any particular amount of disease caused by employment even in the most objectionable branches of the industry which have to do with rag sorting and grinding, which will be subsequently considered as a separate occupation.

THE RAG INDUSTRY.

Rag collecting, sorting, and grinding, for subsequent use in paper mills, shoddy factories, and for other industrial purposes, include a group of occupations peculiarly exposed to the risk of dust inhalation, but where the dust is of such a mixed character that it is extremely difficult to define with accuracy the quality of the dust or the character of its ingredients. The conditions under which this work is carried on vary so widely, according to locality and circumstances, that no definite line can be drawn. The employment has always attracted the attention of those who have written on the hygiene of occupations, chiefly because of the low status of the persons employed and the high degree of theoretical risk to infectious diseases, and the probably health-injurious results otherwise due to the continuous and considerable inhalation of health-injurious dust. Since previous references have been already made to this employment in discussing paper and shoddy manufacture, it is only necessary here to very briefly restate the general facts of the sanitary aspects of the industry as they have been presented by the most recent authorities on the subject.

Dr. B. W. Richardson, writing in 1876, referred to an earlier article in the Journal of Public Health for January, 1859, by Mr. J. J. Murray, of Edinburgh, who had investigated the health of those who worked among rags, including such as collected junk and other second-hand materials. According to Richardson, "Mr. Murray expected, very naturally, that he should find amongst the workers in these tattered and filthy stores some suffering from contagion, others from the products of decay of the animal and vegetable constituents of the rags; others from inhaling and swallowing dust. An inquiry made by him at twenty-three paper mills to which rags were sent and of twenty-three rag collectors in Edinburgh led to the curious return that epidemic or contagious disease from this source was practically unknown amongst workers in rags, that there was no evidence of disease from the decomposition, but that some workers suffered from bronchial affections, cough, and shortness of breath from inhaling the dust which is cast off in large quantities from the rags, when they are made to revolve in the wire-cloth cylinder which is used to free them from dirt and dust." The paper makers of whom inquiry was made as to diseases met with among workers in rags were of the opinion that, with the exception of the effects of dust, there was no unfavorable circumstance, and they referred to one employer who, during thirty years, with an average of 10 employees handling 200 tons of rags a year, reported only one death during a period of ten years.([a]) Many similar investigations made during the intervening period have led to very much the same conclusions. There is no doubt that infectious diseases are conveyed through rags, and the experience in Massachusetts, at least at Holyoke, has been to the effect that outbreaks of smallpox have been of greater frequency in that locality than in any other portion of the State, while according to D'Arcy Power, writing in Oliver's Dangerous Trades, "anthrax or charbon, sometimes known as splenic fever, or malignant postule," is occasionally conveyed through rags to rag sorters, upholsterers, mattress makers, etc., but cases of this disease, in this country at least, have been extremely rare.

Dr. John A. E. Stuart, in an article on "Rags and their products in relation to health," contributed to the same work on dangerous trades, expressed the opinion that people who sorted rags were occasionally bronchitic and asthmatic from the dust which arises from them, but he had seldom met with this condition in rag sorters, although he had known individuals who had been compelled to wear respirators when sorting on account of the dust met with in the occupation. He states that—

> In the case of very dirty rags derived from dust heaps, rags which have been exposed to rain in many cases, it is probable that after drying the dust would be of a septic character and might induce sore throat. Rags from surgical hospitals are decidedly dangerous. Most persons who work as sorters are infested with fleas, which simply swarm among the rags, especially the mungo variety.

Thomas Oliver, M. D., in his treatise on Diseases of Occupation, after observing that rag sorters in England are generally women and that the work is anything but pleasant, states that—

> This is especially the case with woolen rags, for they so frequently harbor fleas and other pests. All bundles of rags before being opened ought, therefore, to be first disinfected so as to destroy para-

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[a] Scientific American Supplement, No. 10, March 4, 1876.

sites, and since rags from the surgical wards of hospitals and private patients often contain septic material, the importance of making disinfection obligatory is at once apparent. It is when the bundles are first opened that the danger is greatest. The dust given off is irritating to the respiratory passages and causes dryness of the throat. During the grinding of the rags by machinery considerable quantities of dust are thrown off, inhalation of which is extremely trying to new hands, but which has little or no immediate effects on the older work people. Those persons who are new to the trade develop what is known as "shoddy fever," the symptoms of which are a rise of temperature, severe headache, signs of bronchial catarrh, and running at the nose. The work people shiver as if they were going to have a severe fever, and they complain of muscular pains. The symptoms are not unlike those met with in influenza. They rapidly decline on the work people absenting themselves from the factory for a few days, but they are apt, in many people, to recur on their return to work. Rags which contain a good deal of cotton have to be carbonized by being plunged into a bath of sulphuric or hydrochloric acid. By this means the cellulose or vegetable part of the fiber is destroyed and the wool can be thus extracted from cotton fabrics. When the rags are subsequently heated to dryness and are beaten, a considerable quantity of fine dust is evolved, some of which is inflammable and may be the cause of an explosion.

In this connection a brief reference may be made to the handling of old paper received at paper mills for the purpose of being reconverted into new paper, and which in all essentials resembles the handling, sorting, and grinding of cotton and linen rags. Old paper, according to the report of the Massachusetts state board of health, is received in the form of bales, which are opened by men and sorted by women and girls. It is then conveyed to the duster on an endless belt, and in this machine it is freed from dust and torn into pieces by means of revolving wooden rolls bearing iron pins. The pieces of paper are then sorted over like rags, but are not put through the choppers, passing immediately from the dusters, so called, to an open cooking tub, subsequent to which the dust factor is reduced to a minimum. The results of the investigations by the Massachusetts state board of health are summed up as follows:

From the above description it will have been noted that from the opening of the bales of rags or paper to the cooking process the various steps involve exposure to varying quantities of dust, the greatest amount being given off in the earliest operations. It appears that, no matter how constructed, how carefully inclosed, how well provided with blowers and dust flues, a certain amount of dust is inevitable in the rooms where the threshers and choppers are installed and operated, excepting when unusually clean materials are being handled. If the machines are loosely sheathed or are not adequately equipped with dust-removal devices, the amount given off may be considerable to enormous, according to material. Unless the most dusty rooms are tightly partitioned off from other less dusty ones—

as, for example, a threshing from a sorting room—the amount of dust in the air in the latter must necessarily be augmented. In a number of the mills visited the air of the whole rag department was observed to be filled with dust and lint.

The character of the dust brought in with rags varies considerably, as would naturally be surmised from their many different places of origin. Some of the employees state that while at first they suffered from sore throat, cough, and loss of sleep, after a time they became so habituated that only an occasional bale causes any discomfort. In some mills it was observed that the dust was far more irritating than that met with in others; especially is this true of those in which burlap is used. Some men assert that the dust from rags of one color may be worse than that from the same kind of cloth differently dyed. Some say that some bales are sickening in their effects, even to old hands.

Of the threshing rooms visited, a very small number, in which the machines were exceptionally good and where the cleanest grade of rags were being handled, showed no dust; somewhat more, equipped with the same grade of machines and working on the same kind of material, showed but little dust; and the remainder showed considerable to much. About 11 per cent of the sorting rooms were dustless, about 25 per cent were not very dusty, and the balance showed considerable to much. Of the cutting rooms, about 7 per cent showed little or none and the remainder considerable to much. In a number of establishments sorting is conducted in large, airy, well-lighted, mechanically ventilated rooms; but in some of these cutting machines have been installed, and they create considerable dust. Indeed, in the matter of separation of the several processes mills vary; in some the duster and cutter machines are installed in separate rooms, in some they are in the same room.

In a majority of the mills visited a portion of the employees are exposed to an excessive quantity of dirt, dust, and lint; and in most of this majority the persons so exposed show not a few who are pale and sickly in appearance. In 19 mills girls under 18 years of age were noted as being employed, in no great numbers, in rooms which were very dusty.

In the department where the paper is actually made there is no dust, but the temperature is sometimes excessive and the air saturated with moisture. The latter condition is not only promotive of discomfort, but exposes the paper to damage through condensation and dropping, wherefore exhaust ventilation is commonly resorted to.

The paper industry, being one which exposes its followers to every kind of dust and dirt which can be carried in rags, is naturally looked upon by many as a dangerous trade. It is unfortunate that it is impossible from statistics available to determine in what relation this industry stands to others of the dusty occupations. The death certificates of the city of Holyoke, the center of the business in this State, were examined; but they proved to be too indefinite for use, since the terms "paper worker" and "mill hand" are commonly applied to all employees, whether engaged in the dusty or nondusty processes. Comparing, however, the death rates from tuberculosis, pneumonia, and bronchitis during the years 1901–1904 with those of the State at large, it was found that the Holyoke rates were under, rather than over, the average.

There are no vital statistics of this employment nor any published industrial mortality experience, but the foregoing observations, based upon careful inquiry into the actual conditions under which work is carried on in this branch of industry, would seem to warrant the opinion that there are serious health-injurious circumstances connected with the employment, but for a definite conclusion there are at present no satisfactory statistical data for the United States.

UPHOLSTERERS AND HAIR MATTRESS MAKERS.

Upholstering is a well-defined trade, including the making and renovating of mattresses, but in occupation vital statistics the employment is, as a rule, included with other more or less dissimilar occupations. In the vital statistics of the census of 1890 and that of 1900, as well as in the occupation mortality statistics for England and Wales, upholsterers are included with cabinetmakers, for which there is but very slight warrant in practical experience. As a result the statistics are not entirely determining for cabinetmakers any more than they are conclusive for upholsterers. Since it is rare that a cabinetmaker also performs the duties of an upholsterer, and vice versa, it would seem advisable to consider this occupation entirely separate and distinct, and more so in view of the fact that the exposure to health-injurious dust is chiefly that of vegetable and animal fiber dust in contrast to the exposure to wood and mineral dusts in the work of the cabinetmaker. It is fortunate that in the occupation statistics of the census the employment has been kept separate, and it is of both interest and value to note that out of 28,001 male upholsterers, aged 16 or over, 977, or 3.5 per cent, had attained to ages 65 or over.(a)

The work of the upholsterer consists chiefly in the covering, lining, and stuffing of upholstered furniture, while mattress making and renovating practically constitutes a separate trade. To a limited extent upholsterers are employed in the renovating of feather pillows and mattresses, but this practice never has attained to considerable proportions in this country, though it is extensively followed abroad. Mattresses are made chiefly of curled hair, moss, corn husks, straw, and flock, and the conditions vary so much that it is very difficult, if not next to impossible, to define with accuracy the kind of dust to which upholsterers are chiefly exposed. Both Arlidge and Oliver have discussed the hygiene of the upholsterer's trade. Arlidge points

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[a] Report of the Twelfth Census on Occupations, page 18.

out that the upholsterer's occupation is one which is concerned with the handling of feathers, flock, down, hair, etc., each and all being materials laden with dust and almost necessarily productive of respiratory troubles, particularly in the preparatory operation of cleansing by means of beating and washing. Arlidge treats at some length of flock making, which has been referred to under "shoddy manufacture." Of the large number of miscellaneous materials used by upholsterers, all of which are more or less productive of dust during the necessary manipulation, Arlidge mentions horse and cow hair, feathers, wool waste, cotton, flock, refuse of raw cotton, straw, cocoanut fibers, and seaweed. Most of these substances, in his opinion, are harmless unless they have been previously used or in some other way have acquired infectious qualities. Oliver is also of the opinion that the dust of feathers, flock, hair, etc., as produced in the upholsterer's occupation, is provocative of respiratory troubles. He holds that if the rags, feathers, and hair have not been previously cleansed the dust not only causes bronchial irritation, but may be the means of causing infectious diseases, such as smallpox, erysipelas, and intestinal derangements, such as vomiting and diarrhea.

Oliver refers to the manufacture of mattresses as an unhealthful occupation on account of the dust that escapes from wool and horsehair during the operation of carding, causing cough, difficulty in breathing, and retching, and if the materials have not been properly sterilized the dust may, in his opinion, cause blood poisoning. He refers to a well-known reference in the treatise by Ramazzini on the diseases of the Jews, who were at that time engaged chiefly in the handling or remaking of old materials, just as at the present time the secondhand trade is practically limited to the Hebrew race. Ramazzini states that in the beating of the old wool, which had been daubed with filth, a great deal of dust was inhaled, which disposed the workmen to a violent cough and a difficulty of breathing, and that he himself had observed those who had followed this occupation to have reduced themselves to an incurable consumption.

The reference to this aspect of the employment by Oliver is as follows:

> Mattresses that have been lain upon by persons who have died of infectious diseases occasionally find their way into third-rate upholsterers' shops, where their contents are picked and mattresses are remade. It is very dusty work when the picking is done by hand, and, besides, there escapes an unpleasant, sickening odor which causes headache and a feeling of malaise. When mattresses have become fouled in places by discharges from patients suffering from infectious diseases, considerable risk is incurred by those who by hand tease the contents of such bespoiled bedding.

In the Southern States large quantities of so-called Spanish moss are gathered and subjected to a process known as moss ginning, to prepare the material for mattress making and other purposes in upholstery, either alone or as a mixture with hair or other products. The work is extremely dusty, and the character of the dust inhaled has not been properly determined, consisting, however, chiefly of earthy matter and vegetable fiber.

The upholsterer's employment has been already referred to in the discussion of the vital statistics of cabinetmakers, and while the statistical facts can not be separately stated the employments, as a group, are evidently subject to a decidedly high mortality from consumption. The results of the census investigation in 1890 were fully confirmed by the subsequent census returns for 1900, proving that the death rate of cabinetmakers and upholsterers as a group was excessive from consumption and other diseases of the respiratory system. Since only the rates for 1900 were referred to under cabinetmakers, the rates for 1890 are here included. The consumption death rates of cabinetmakers and upholsterers during that year were 4.57 per 1,000 in the registration States, and nearly 5 per 1,000 in the registration cities only, while the mortality from other respiratory diseases as a group was 3.03 per 1,000 in the registration States and 3.45 in the registration cities.

The occupation mortality statistics of Rhode Island for the decade 1897 to 1906 returned only 25 deaths of upholsterers from all causes. Of this number, 6, or 24 per cent, were from consumption, against 17.8 per cent expected on the basis of the mortality of all occupied males in the State. The mortality from respiratory diseases other than consumption was returned as 3 deaths, or 12 per cent of the total, against 12.5 per cent expected. Of the total mortality of upholsterers, 9 deaths, or 36 per cent, were from diseases of the lungs and air passages, against a normal expected proportion of 30.3 per cent for all occupied males in Rhode Island.

The recorded industrial insurance mortality statistics of upholsterers include 381 deaths, of which 118, or 31 per cent, were from consumption. Of the mortality of upholsterers from respiratory diseases other than consumption, 33 deaths were from pneumonia, 5 from asthma and bronchitis, and 8 from less frequent respiratory diseases. If the deaths from consumption and from other respiratory diseases are combined, it is found that 43 per cent of the mortality of upholsterers was from disease of the lungs and air passages. The excess in the consumption mortality of upholsterers is still more clearly brought out in the tabular presentation of the proportionate mortality from this disease by divisional periods of life. While the consumption mortality was excessive at all ages, the excess was most pronounced at 25 to 34, when, out of every 100 deaths from all causes, 58.5 were from consumption, against a normal expected proportion of 31.3. The analysis of the consumption mortality of upholsterers in detail is set forth in the following table:

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG **UPHOLSTERERS**, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for upholsterers from experience of an industrial insurance company; figures for males in the registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of upholsterers, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Upholsterers.	Males in registration area, 1900 to 1906.
15 to 24 years	39	15	38.5	27.8
25 to 34 years	65	38	58.5	31.3
35 to 44 years	79	38	48.1	23.6
45 to 54 years	73	18	24.7	15.0
55 to 64 years	62	3	4.8	8.1
65 years or over	63	6	9.5	2.7
Total	381	118	31.0	14.8

The recorded industrial insurance mortality statistics of mattress makers include 41 deaths, of which 16, or 39 per cent, were from consumption. There were 6 deaths of mattress makers from respiratory diseases other than consumption, all of these having been caused by pneumonia. If the deaths from consumption and from other respiratory diseases are combined, it is found that 53.7 per cent of the total mortality of mattress makers was from diseases of the lungs and air passages. While the aggregate number of deaths of mattress makers is too small to warrant final conclusions, the statistics are given in detail for the reason that mattress making and upholstering are closely related and the consideration of the two employments may very properly be combined. The consumption mortality of mattress makers is shown to have been in excess of the normal at all ages and in this respect the statistics confirm those for upholsterers. The analysis of the mortality of mattress makers from consumption is set forth in detail in the table below:

PROPORTIONATE MORTALITY FROM CONSUMPTION AMONG **MATTRESS MAKERS**, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for mattress makers from experience of an industrial insurance company; figures for males in the registration area computed from mortality statistics of the United States census.]

Age at death.	Deaths of mattress makers, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Mattress makers.	Males in registration area, 1900 to 1906.
15 to 24 years	9	4	44.4	27.8
25 to 34 years	7	3	42.9	31.3
35 to 44 years	11	4	36.4	23.6
45 to 54 years	5	2	40.0	15.0
55 to 64 years	8	3	37.5	8.1
65 years or over	1			2.7
Total	41	16	39.0	14.8

The available information confirms the conclusion that upholsterers and mattress makers as a class are subject to an excessive mortality from consumption, but in particular at ages 15 to 54, and this excess, in view of the conditions of labor briefly described, is in a large measure the result of health-injurious circumstances connected with the employment.

SUMMARY OF CONCLUSIONS REGARDING OCCUPATIONS WITH EXPOSURE TO ANIMAL AND MIXED FIBER DUST.

In the preceding observations and statistical data nine specific occupations with exposure to animal and mixed fiber dusts have been considered in more or less detail. The data for some of the occupations are too meager to warrant final conclusions, but the information here presented is decidedly suggestive of health-injurious conditions in certain of these occupations.

The United States census returns of 1900 give the age distribution of hat and cap makers, silk operatives, woolen mill operatives, carpet factory operatives, and upholsterers, the aggregate number of the males of known ages 15 years of age or over being 114,485. Of this number only 2,805, or 2.5 per cent, had attained to the age of 65 years or over, against a normal expected proportion of 4.6. This fact is decidedly suggestive of conditions more or less unfavorable to health and life in occupations exposing to animal and mixed fiber dusts. The details of the age distribution are given in the following table, by divisional periods of life, together with the corresponding percentage distribution of all occupied males, the data for both groups being derived from the United States census of 1900:

NUMBER AND PER CENT OF MALES IN EACH AGE GROUP IN **OCCUPATIONS EXPOSED TO ANIMAL AND MIXED FIBER DUSTS**, COMPARED WITH THE NUMBER AND PER CENT IN ALL OCCUPATIONS IN THE UNITED STATES, 1900.

[From report of the Bureau of the Census on Occupations, 1900.]

Age.	Males in occupations exposed to animal and mixed fiber dusts.		All occupied males.	
	Number.	Per cent.	Number.	Per cent.
65 to 24 years	38,748	33.8	5,933,720	26.0
15 to 34 years	31,928	27.9	5,993,847	26.3
25 to 44 years	22,096	19.3	4,704,682	20.6
35 to 54 years	12,532	10.9	3,250,259	14.3
45 to 64 years	6,376	5.6	1,856,181	8.1
55 years or over	2,805	2.5	1,063,856	4.7
Total	114,485	100.0	22,802,545	100.0

According to this analysis the proportion of males aged 15 to 34 was 61.7 per cent, or nearly two-thirds of the total number in occupations exposed to animal and mixed fiber dusts, against 52.3 per cent for all occupied males. The percentage of occupied males in this group of occupations living at age 35 or over was therefore much less than would be expected on the basis of all occupied males. The actual age distribution would indicate that the conditions of employment in the various occupations considered predispose more or less to a high mortality largely the result of exposure to health-injurious dust.

It is impossible to present a combined summary of the United States census vital statistics of persons employed in the occupations considered in this group. The only occupation for which the facts are given in the census returns is the group entitled hat and cap makers. The vital statistics for this class of employees, when compared with those for occupied males generally, are very suggestive of unfavorable health conditions in occupations exposing to animal and mixed fiber dusts. The death rates of male hat and cap makers are shown to be higher than for all occupied males at all the divisional periods of life for which the facts are obtainable in the census returns. At ages 15 to 24 the general death rate per 1,000 of hat and cap makers was 5.4 against 5.1 expected; at ages 25 to 44 the rate was 13.1 against 8.8 expected; at ages 45 to 64 the rate was 32.9 against 19.9 expected; and at ages 65 or over the death rate of hat and cap makers was 173.1 against 98.4 expected. The death rate per 1,000 employees from consumption was 4.2 for hat and cap makers, according to the census returns, against 2.4 expected; and the death rate from respiratory diseases other than consumption was 2.6 against 2.0 expected.

The details of the mortality of male hat and cap makers by age groups are given in the following table, together with the corresponding death rates for all occupied males, all of the data being derived from the United States census of 1900:

MORTALITY FROM ALL CAUSES AMONG MALE **HAT AND CAP MAKERS** IN THE REGISTRATION STATES, COMPARED WITH THAT OF ALL OCCUPIED MALES IN THOSE STATES, 1900, BY AGE GROUPS.

[From the report of the Bureau of the Census on Vital Statistics, 1900.]

Age.	Male hat and cap makers.			All occupied males.		
	Number employed. [a]	Number of deaths from all causes.	Rate per 1,000 from all causes.	Number employed.	Number of deaths from all causes.	Rate per 1,000 from all causes.
15 to 24 years	3,148	17	5.4	1,259,471	6,486	5.1
25 to 44 years	7,023	92	13.1	2,680,241	23,541	8.8
45 to 64 years	2,249	74	32.9	1,282,259	25,532	19.9
65 years or over	260	45	173.1	283,310	27,888	98.4
Total	12,680	228	[b] 18.0	5,505,281	83,447	[c] 15.2

[a] The actual numbers employed in each age group are not given in the census report on vital statistics. The numbers here given are estimated by dividing the number of deaths by the death rate, as shown in the census, and multiplying the quotient by 1,000.

[b] From consumption there were 53 deaths, or a rate of 4.2; from other diseases of the respiratory system there were 33 deaths, or a rate of 2.6.

[c] The rate of mortality from consumption was 2.4; from other diseases of the respiratory system, 2.0.

The occupation mortality statistics of Rhode Island are available for only two specific occupations in this group, upholsterers and wool sorters. A considerable number of persons are employed in woolen and worsted mills in Rhode Island, but they are returned in the mortality statistics under general terms, such as operatives, spinners, weavers, etc., and the more important of these groups have been already considered in the discussion of cotton mill employees. In Rhode Island during the decade 1897 to 1906, upholsterers and wool sorters combined returned only 62 deaths from all causes. Of this number 11, or 17.7 per cent, were from consumption, against 17.8 expected on the basis of occupied males generally in Rhode Island. The mortality from respiratory diseases other than consumption in the two occupations of this group was 8, or 12.9 per cent, against 12.5 per cent expected. These numbers are too small to form the basis for a final conclusion, but the facts are presented to make the analysis complete.

The English vital statistics for this group of occupations are available for furriers, hatters, silk mill employees, woolen and worsted mill employees, and carpet and rug makers. When the statistics for these occupations are combined they exhibit high death rates from all causes at ages 20 to 24 and at ages 45 or over. The details are set forth in the following table:

MORTALITY FROM ALL CAUSES, FROM CONSUMPTION, AND FROM OTHER DISEASES OF THE RESPIRATORY SYSTEM IN **OCCUPATIONS EXPOSED TO ANIMAL AND MIXED FIBER DUSTS**, COMPARED WITH THAT OF ALL OCCUPIED MALES, IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 due to all causes among—		Death rate per 1,000 due to consumption among—		Death rate per 1,000 due to other diseases of the respiratory system among—	
	All occupied males.	Occupations exposed to animal and mixed fiber dusts.	All occupied males.	Occupations exposed to animal and mixed fiber dusts.	All occupied males.	Occupations exposed to animal and mixed fiber dusts.
15 to 19 years.....	2.44	2.38	0.54	0.61	0.24	0.32
20 to 24 years.....	4.41	5.07	1.55	2.49	.48	.29
25 to 34 years.....	6.01	5.56	2.03	2.20	.77	.72
35 to 44 years.....	10.22	9.48	2.74	2.68	1.66	1.45
45 to 54 years.....	17.73	17.78	3.04	3.24	3.32	3.13
55 to 64 years.....	31.01	37.33	2.16	2.65	6.54	7.02
65 years or over...	88.39	120.64	1.11	1.81	17.77	25.12

The table shows that the mortality from consumption among men in occupations with exposure to animal and mixed fiber dusts was excessive at all ages except 35 to 44, when the consumption mortality rate was 2.68 for the occupations of this group, as against 2.74 for all occupied males. The excess in the mortality from consumption was highest at ages 20 to 24, when the rate was 2.49 for the occupations of this group against 1.55 for all occupied males. The mortality from respiratory diseases other than consumption was somewhat fluctuating when compared with the corresponding rates for all occupied males; nevertheless the differences were slight, except at ages 65 or over, when the mortality for the combined occupations of this group was 25.12 per 1,000 against 17.77 for all occupied males.

The industrial insurance mortality statistics are available for seven occupations included in this group, returning in the aggregate 1,915 deaths of males from all causes at ages 15 or over. Of this number 615, or 32.1 per cent, were from consumption. The deaths from respiratory diseases other than consumption numbered 242, or 12.7 per cent. The expected consumption mortality on the basis of the mortality of males in the registration area of the United States for the seven-year period 1900 to 1906 was 14.8 and the expected mortality from other respiratory diseases was 11.7. When the mortality from consumption and from other respiratory diseases is combined the proportionate percentage of deaths of males in occupations with exposure to animal and mixed fiber dusts is found to be 44.8 against 26.5 expected. The following table gives the summary statistics in detail for the seven occupations in this group for which the industrial insurance mortality experience is available:

PROPORTIONATE MORTALITY FROM CONSUMPTION IN **OCCUPATIONS EXPOSED TO ANIMAL AND MIXED FIBER DUSTS**, 1897 TO 1906, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[Figures for deaths in occupations exposed to animal and mixed fiber dusts are from experience of an industrial insurance company; figures for males in registration area are computed from mortality statistics of the United States census.]

Age at death.	Deaths in occupations exposed to animal and mixed fiber dusts, 1897 to 1906, due to—		Per cent of deaths due to consumption among—	
	All causes.	Consumption.	Occupations exposed to animal and mixed fiber dusts.	Males in registration area, 1900 to 1906.
15 to 24 years	248	106	42.7	27.8
25 to 34 years	364	194	53.3	31.3
35 to 44 years	391	189	48.3	23.6
45 to 54 years	292	74	25.3	15.0
55 to 64 years	324	39	12.0	8.1
65 years or over	296	13	4.4	2.7
Total	1,915	[a] 615	[a] 32.1	[b] 14.8

[a] There were also 242 deaths from other diseases of the respiratory system, or 12.7 per cent of the deaths from all causes.

[b] The per cent of deaths from other diseases of the respiratory system in the registration area was 11.7.

It is evident from the foregoing observations and statistical data relating to typical employments with exposure to animal and mixed fiber dusts that the effects of such exposure are injurious to health, and particularly so in early life. The summary table shows that the mortality from consumption of employees in this group of occupations is from 50 to 100 per cent higher at all ages than would normally be expected.

GENERAL SUMMARY OF RESULTS.

A general summary of the preceding observations and statistical data does not seem necessary for the present purpose, which is to emphasize the degree of consumption frequency in different occupations rather than the differential degree of lung injury resulting from exposure to particular kinds of dust. In an address on "Tuberculosis as an industrial disease," read before the Sixth International Congress on Tuberculosis, by the writer, the latter aspect of the problem was enlarged upon to a certain extent. The discussion was limited, however, to industrial insurance mortality experience, at the same time including occupations exposing also to general organic and municipal or street dust, which it was not feasible to include in the present discussion. From the address referred to the following extract is made:

> When all the occupations for which the information is available, inclusive of many other than the thirty employments considered in this discussion, are combined, the proportionate mortality from consumption is 28.0 per cent of the mortality from all causes at ages 15 and over. In the group of occupations exposing chiefly to the inhalation of metallic dust the proportionate mortality from consumption was 37.4 per cent; in occupations exposing to animal and mixed fiber dust, 32.3 per cent; in occupations exposing to mineral dust, 28.6 per cent; in occupations exposing to municipal or street dust, 27.5 per cent; in occupations exposing to vegetable fiber dust, 27.4 per cent; and in occupations exposing to organic dust, 23.7 per cent. These percentages of consumption frequency are derived from an analysis of 22,987 deaths from all causes in the occupations included in the investigation.
>
> The analysis may be extended to divisional periods of life, to emphasize the more immediate effects of health-injurious dust inhalation, and beginning with ages 15 to 24 the proportionate mortality from consumption was highest in occupations exposing to the inhalation of animal and mixed fiber dust, or 49.6 per cent of the mortality from all causes. In occupations exposing to metallic dust it was 47.1 per cent; to organic dust, 40.9 per cent; to municipal or street dust, 39.8 per cent; to vegetable fiber dust, 39.1 per cent; and to mineral dust, 31.7 per cent.
>
> At ages 25 to 34 the proportionate mortality from consumption was highest in occupations exposing to the inhalation of metallic dust, or 56.7 per cent of the deaths from all causes. In occupations exposing to the inhalation of vegetable fiber dust it was 53.3 per cent; of organic dust, 50.1 per cent; of animal and mixed fiber dust, 49.7 per cent; of mineral dust, 47.6 per cent, and of municipal or street dust, 43.5 per cent.
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> At ages 35 to 44 the proportionate mortality from consumption was highest in occupations exposing to the inhalation of metallic dust, or 43.0 per cent of the deaths from all causes. In occupations exposing to the inhalation of animal and mixed fiber dust it was 40.4 per cent; of vegetable fiber dust, 39.8 per cent; of mineral dust, 36.3 per cent; of organic dust, 36.2 per cent, and of municipal or street dust, 34.6 per cent.
>
> At ages 45 to 54 the proportionate mortality from consumption was highest in occupations exposing to the inhalation of mineral dust, or 27.9 per cent of the deaths from all causes. In occupations exposing to the inhalation of metallic dust it was 23.6 per cent; of animal and mixed fiber dust, 23.2 per cent; of vegetable fiber dust 22.9 per cent; of organic dust, 21.9 per cent, and of municipal or street dust, 14.2 per cent.
>
> At ages 55 to 64 the proportionate mortality from consumption was highest in occupations exposing to the inhalation of mineral dust, or 16.2 per cent of the deaths from all causes. In occupations exposing to the inhalation of vegetable fiber dust it was 11.6 per cent; of metallic dust, 11.5 per cent; of organic dust, 11.4 per cent; of animal and mixed fiber dust, 11.2 per cent, and of municipal or street dust, 10.8 per cent.

At ages 65 and over the proportionate mortality from consumption was highest in occupations exposing to the inhalation of mineral dust, or 6.8 per cent of the deaths from all causes. In occupations exposing to the inhalation of organic dust it was 4.6 per cent; of metallic dust, 3.8 per cent; of animal and mixed fiber dust, 3.7 per cent; of vegetable fiber dust, 3.7 per cent, and of municipal or street dust, 2.9 per cent.

From the same address is quoted the following concluding portion summarizing the social and economic aspects of the tuberculosis problem in its relation to American industry:

The problem of occupation mortality and tuberculosis, with special reference to that period of life at which the degree of consumption frequency is most excessive, may now be briefly restated as follows: The census mortality rate of 1900 for men in gainful occupations was 15.0 per 1,000 and the consumption death rate 2.4 or 16.0 per cent of the mortality from all causes. Among men in manufacturing and mechanical industries the general death rate was 13.8 per 1,000, and the consumption death rate 2.6, or 18.8 per cent of the mortality from all causes. Among men in agricultural, transportation, and other outdoor occupations (including, however, a considerable proportion of persons of advanced years) the general death rate was 15.8 per 1,000, and the consumption death rate 1.5, or 9.5 per cent of the mortality from all causes. Contrasting the consumption death rates in these two groups of employments, the enormous waste of human life in industry becomes readily apparent. If the consumption mortality in dusty trades could be reduced to the corresponding proportion for men in outdoor occupations, a very large number of lives would be saved and continue for many years, which are now, to a large extent, needlessly wasted. The problem may be emphasized by a few specific illustrations of occupations exceptionally exposed to the risk of dust inhalation. The census mortality rate for marble and stone cutters was 14.9 per 1,000, and the consumption death rate 5.4, or 36.2 per cent of the mortality from all causes. The general death rate of cigar makers was 18.7 per 1,000, and the consumption death rate 4.8, or 27.7 per cent of the deaths from all causes. The general death rate of printers and compositors was 12.1, and the consumption death rate 4.4, or 36.4 per cent of the mortality from all causes, while for the strictly outdoor labor class, that is, farmers, planters, and farm laborers, the general death rate was 17.6 per 1,000, but the consumption death rate was only 1.1, or 6.25 per cent of the mortality from all causes. Granting that these rates are not entirely trustworthy, and that the census method of mortality investigation at that time was not as technically perfect as it is at present, and granting further that all occupation mortality data have their inherent defects, when derived from general methods of population enumeration and the methods in vogue in the registration of deaths, there is not the slightest reason to question the approximate accuracy of the foregoing rates and conclusions, which are in strict conformity to the other facts previously presented.

Estimating the wage-earning population (males and females) of the United States at ages 15 or over for 1908 at 31,768,943, and assuming a consumption death rate among this element of the population of 2.2 per 1,000,(a) the number of deaths from consumption among wage-earners during 1908 would be approximately 69,892. Since it is possible by intelligent factory inspection and control, and with special regard to ventilation (that is, the removal of injurious dust particles at the point of their origin) to almost entirely eliminate the conditions injurious to health and life in factories and workshops and industry generally, it is not going too far to advance it as a fundamental principle of sanitary legislation that the consumption death rate among wage-earners can be reduced, by intelligent methods, to a ratio as low as 1.5 per 1,000.(b) On the above basis such a reduction would result in an annual saving of approximately 22,238 human lives. Since the average age at death of persons 15 years of age or over dying from consumption in the registration area of the United States is 37.4 years and probably not much more than 32 years for persons employed in strictly dusty trades, and since the normal average age at death in the mortality from all causes for persons 15 years of age or over is 52.8 years, there would be an average expected gain of at least 15.4 years of life for every death from consumption avoided by rational conditions of industrial life. Such a gain would represent a total of 342,465 years of additional lifetime, and by just so much the industrial efficiency of the American nation would be increased. If we place the economic value or net result of a year's lifetime at only $200, the total average economic gain to the nation would be $3,080 for every avoidable death of a wage-earner from consumption, representing the enormous total of $68,493,000 as the aggregate annual financial value in the probable saving in years of adult human life. With such results clearly within the range of practical attainment, nothing within reason should be left undone as a national,

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[a] This rate is based upon the number of gainfully employed persons (male and female) 10 years of age or over in the registration States in 1900 and the number of deaths among that element of the population during the census year. Unfortunately it has not been possible to calculate the corresponding consumption death rate for persons gainfully employed of ages 15 or over, as the necessary data were not included in the census reports. The consumption death rate of 2.2, however, would be raised rather than lowered if it were possible to get at the facts, because the consumption death rate is lower at ages 10 to 14 than at ages 15 or over. The calculations based upon the consumption death rate of 2.2 per 1,000 of the gainfully employed are therefore conservative, being in all probability rather an under than an over statement of the facts.

[b] See article on "Mortality from consumption in small cities," by Frederick S. Crum, in Quarterly Publications of the American Statistical Association for December, 1907, pp. 448–479. In this article, which is based on the mortality statistics of the United States census, it is shown that the average annual death rate from consumption in 209 small cities in the United States for the years 1901 to 1905 was 1.58 per 1,000, and in 30 of these cities the rate was below 1.0 per 1,000. If nine cities with over 15 per cent of Negro population are discarded it is shown that the consumption mortality for the remaining 200 small cities was 1.51 per 1,000.

state, and individual, or social duty to prevent that needless, but now enormous, loss of human life from consumption due to unfavorable conditions in American industry.

THE PROBLEM OF VENTILATION AND DUST REMOVAL IN INDUSTRY.

The statistical evidence presented in the preceding discussion of dusty trades is entirely conclusive that an excessive degree of consumption frequency in any particular occupation depends primarily or largely on the kind and quantity of dust inhaled by the workmen. All who have written upon the subject with authority emphasize the importance of adequate ventilation and dust reduction or removal by artificial means and methods, but the most conclusive evidence has been presented in two reports of an English departmental committee appointed to inquire into the ventilation of factories and workshops, the first being published in 1902, the second in 1907. The reports warrant the conclusion that effective ventilation of factories and workshops and the artificial removal of dust at the point of origin is entirely practicable and possible at moderate expense. Since these reports are not generally accessible, they are here quoted from at some length. The committee in its first report, in part, said as follows:

> It is evident that the air breathed by the employees in a factory or workshop can be kept pure in two ways: (1) By constantly renewing from outside the whole of the air of the room in which work is carried on; (2) by removing impurities locally, or otherwise preventing them from ever mixing with the air breathed. The former process may be distinguished as general and the latter as local ventilation. As a general rule, dust and fumes can best be dealt with by local ventilation or by other means, whereas impurities due to the presence of employees and of lights burning must be got rid of by general ventilation.

The first report was limited to considerations of general ventilation, while the second considered at length the problem of local ventilation and other means of preventing injury to health by dust and fumes. The committee called attention to the agreement of authorities that health depends to a large extent on a constant and abundant supply of air which is uncontaminated by any substances which would cause discomfort or which contain poisonous, infective, or otherwise harmful material. By section 7 of the Factory and Warkshop Act, 1901, it was provided that "in every room in any factory or workshop sufficient means of ventilation shall be maintained," and, further, that "the secretary of state may, by special order, prescribe a standard of sufficient ventilation for any class of factories or workshops, and that standard shall be observed in all factories and workshops of that class." A large number of orders have been issued under the provisions of this act, which unquestionably have resulted in a very material improvement in the conditions affecting health and industry.

Since the present discussion is limited to dusty trades, the observations and recommendations of the committee with reference to the purity of the atmosphere in factories and workshops otherwise than by the impairment of such purity through dust-generating processes as cause or effect inseparable from the conditions under which work is carried on, are passed over. One very suggestive paragraph from the report with reference to the practical difficulties confronting efforts at adequate ventilation in the case of sedentary occupations is quoted, but the objection on the part of employees to proper ventilation depends sometimes on the absence of proper warming arrangements during cold weather. The committee points out that—

> This often leads to further vitiation of the air through the lighting of gas-burners for heating purposes during the day, a wasteful and objectionable plan. The establishment of a legal maximum limit of carbonic acid would probably conduce to the provision and use of proper heating appliances in such cases. We are of opinion that heating arrangements capable of maintaining in case of necessity a temperature at least 25° F. above that of the outside air, in the absence of lights and employees, but along with adequate ventilation, should be provided in all factories and workshops where the occupation is sedentary or involves little muscular exertion, and should be regularly used in the colder weather. In such occupations the temperature should not be less than about 60° F., particularly where the work involves delicate manipulations with the hands.

In the evidence appended to the first report the committee included the results of a scientific examination of the problem of ventilation in clothing factories, tailoring workshops, dressmaking and millinery workshops, boot and shoe workshops, laundries, cabinet and upholstery works, in establishments engaged in the making of bread, confectionery, and articles of food, letterpress printing, bookbinding, the manufacture of stationery and cardboard boxes, engineering and metal trades, file cutting, and the manufacture of the different varieties of textiles. The evidence collected was of a highly scientific and conclusive character, and the methods of inquiry employed are suggestive of the corresponding methods required for the proper determination of the circumstances injurious to health and life in all dusty trades.

In the second report the committee dealt with the application of fans to factory ventilation in connection, more particularly, with the removal of dust, steam, fumes, and other impurities associated with other manufacturing processes, and also with the very important question of the use of respirators by workmen engaged in occupations which can not be successfully subjected to artificial methods of ventilation and dust removal. The committee discussed at considerable length the highly technical aspects of ventilating engineering, including the selection of fans and the relative utility of low and high pressure fans according to particular circumstances inseparable from the conditions under which given industries are carried on. It considered the volume of air required for different purposes of ventilation and the arrangement of inlets and outlets, fully illustrating its observations by a large number of charts and diagrams which clearly emphasized the strictly scientific manner in which the investigations of the committee were made to secure the practical solution of the problems which confronted them. From the remarks regarding general ventilation some of the more important and suggestive extracts are here quoted:

Certain impurities can hardly be prevented from becoming generally distributed in the air of a room, and can thus only be dealt with by general ventilation of the room. In most cases this is true of the products of respiration and of combustion of gas, the water evaporated in wet processes, and the heat given off from moving or artificially heated machinery, and in some cases of the production of dust. In removing these impurities, or sources of inconvenience, the supply of air must be sufficient for the particular purpose in view. If, for instance, heat or dust has to be removed, the ventilation must be sufficient to effect this removal, and not merely to dilute the products of respiration.

The quantity of air required to remove excessive heat and moisture can not well be calculated in the same way, as the loss of heat through walls and roof is usually not known, and in any case varies with the weather. The air supply must therefore be regulated with the help of thermometers. Air in which the reading by the wet-bulb thermometer exceeds about 70° begins to cause serious inconvenience with ordinary clothing, and this limit ought not to be exceeded in factories or workshops except under exceptional conditions.

Experiments show that if the wet-bulb reading rises beyond about 88° in fairly still air, the body temperature can no longer be prevented from rising seriously even in persons stripped to the waist and doing no work; and with muscular work under the same conditions the body temperature may rise rapidly at a wet-bulb temperature of 80°. With ordinary clothing this effect is considerably greater. At the upper limits it is not the temperature of the air, but that of the wet-bulb thermometer, that matters; and, provided that the air is so dry that the wet-bulb temperature does not exceed the limits specified, air temperatures up to 130° or more can be tolerated without rise of bodily temperature. Much higher wet-bulb temperatures can of course be borne for short periods, but the body temperature soon rises seriously.

In removing steam from rooms it must be borne in mind that cold air is apt to cause condensation of aqueous vapor. Thus if air saturated with moisture at 80° is mixed with even ten times its volume of air from outside at 40° condensation will nevertheless usually occur, and will always do so, whatever the dilution, if the incoming air is saturated with moisture at the outside temperature. If, however, the incoming air be warmed to a moderate extent as it enters,

> this condensation will be prevented, and the ventilation will serve the double object of cooling the room and preventing condensation. If it is only necessary to prevent condensation of vapor and not to remove heat, the object can often be best attained by providing not extra ventilation, but heating arrangements. In the case of dye works, etc., where the building is often filled with steam from the vats, experience shows that the atmosphere is best cleared and condensation avoided by blowing in air heated by passing through a coil or other form of radiator.
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> As regards removal of dust, the standard of purity aimed at should always be sufficient to prevent injury to health, and should also be such as to prevent inconvenience and enable those employed to be clean when they leave work, after washing, if necessary. Dust from the disintegration of hard stone, steel grinding, etc., is extremely deleterious, and the same may be said of dust containing any poisonous constituent, such as lead. In such cases the dust should, by special means, apart from general ventilation, be entirely prevented from mixing with the general atmosphere of a room; and the same remark applies to all poisonous gases and fumes.
>
> The effect of ventilation on the temperature of a working room during cold weather needs careful regulation. For sedentary work and fine manipulations a temperature of not less than about 60° is required. With lower temperatures the working powers of those present become impaired; and the effects of the low temperature are much increased by drafts. On the other hand, if the work implies active exertion, lower temperatures are permissible; and some kinds of work associated with dust, fumes, etc., can best be performed in sheds open to the air. In general, the more nearly open-air conditions can be attained in any class of work, the better; and, whenever possible, windows should be thrown widely open in summer weather.

Commenting upon the dust problem in particular and its relation to health, it is pointed out in a footnote to the report that it is sometimes difficult to say whether the inhalation of a given variety of dust is definitely injurious. The committee, therefore, held that—

> Dust from any hard stone (such as flint, granite, sandstone, etc.) is undoubtedly very injurious to the lungs, producing a marked predisposition to phthisis. On the other hand, coal dust, cement dust, and probably many other varieties of organic and inorganic dust have by no means the same serious effects. During our inquiry many experiments have been made by Professor Ritchie with a view to finding a means of experimentally distinguishing the more injurious from less injurious dusts, but unfortunately no satisfactory results have as yet been reached.

In the discussion of the problem of local ventilation, the committee came to the conclusion that—

> Dust, fumes, steam, and other impurities unavoidably given off into the air should, wherever possible, be removed locally, and thus prevented from mixing with the general air of the room. Ventilation with this object in view may be distinguished as "local ventilation." Local ventilation is best carried on by means of exhaust fans, which

may be of the propeller type if large ducts and low velocities of air will suffice. In many cases, however, centrifugal fans are essential, and usually they are preferable on account of the liability of propeller fans to be interfered with by wind, etc. Fans used for the removal of corrosive fumes should be efficiently protected from their action. The question of possible injury to bearings or other parts by gritty material, and of possible blockage by fibrous material, should also be borne in mind in selecting a fan.

If dust or fumes are allowed to escape in any quantity into the general atmosphere of a room enormous volumes of air are required to remove or dilute them sufficiently. Great discomfort from cold or else great expense in heating are thus entailed, so that it is in every way preferable to remove them by local ventilation. The nearer to their points of production they can be removed the less will be the quantity of air required, and consequently the less will be the discomfort and expense which they cause.

Dusty machines which can not be completely boxed in should, if possible, be provided with an exhaust sufficiently powerful to draw the dust from exposed parts inward through the machine to an exhaust opening. Wheels used in dry grinding, polishing, etc., should, wherever possible, be inclosed and provided with an exhaust from a centrifugal fan capable of giving a current at high velocity around the exposed part of the wheel. The part of the wheel left open should be as small as is consistent with efficient working.

Dusty operations, such as the transference and packing of dry and dusty material, should, if possible, be carried out by mechanical arrangements boxed in so as to prevent the escape of dust, and combined, if necessary, with local exhaust ventilation. This is extremely important where the material contains some poisonous or harmful substance, such as lead, bichromate of potash, powdered flint, etc. Where such arrangements are not possible thoroughly efficient respirators should be used in the case of dangerous material.

For manipulations by hand in which dust, poisonous spray, or objectionable fumes are given off, working places provided each with a separate exhaust opening can often be arranged. The table at which the work is done should have an exhaust opening cut through it or placed behind it and so arranged that the dust arising from the work is drawn away from the mouth of the person working and into a duct placed beneath or behind the table. The provision of a hood, which may be made of glass, so as not to obstruct the light, greatly helps the action of the exhaust, which must be sufficient to actually prevent the dust from reaching the mouth of the worker. Where the dust requires to be collected a settling chamber under the exhaust opening can sometimes be provided.

Of the important and suggestive remarks of the committee regarding matters of technical detail in the installation of local ventilation, mention is made only of those regarding operations in wool sorting and rag sorting. In these occupations the committee thought the best way to manipulate the dusty material was on a flat-wire grating through which air is exhausted from below. It was held that in such a case the rate of flow at every part of the grating must be sufficient to draw the dust downward, and that the whole arrangement, including inlet ventilation to the room, must be such that this purpose is effected under all conditions, for it was explained that—

> It often occurs that a large dusty machine can not be sufficiently inclosed for the effective application of direct-exhaust ventilation, or that dusty work by hand can not be confined to the immediate neighborhood of an exhaust opening. In these cases air inlets and outlets should be so arranged as to carry off the dust in such a direction as to contaminate as little as possible the air in positions where persons have to be present. The most generally available plan is to have the exhaust openings in the floor around each dusty machine, or as close as possible to whatever the source of the dust may be, and to allow air to enter in an abundant stream from the roof above, warmed if necessary to prevent impact of cold draft on workers. As dust tends naturally to fall to the floor, it is best to remove it downward unless a rapid air current, sufficient to draw it in any direction, is available. If the machine is placed near a wall and no person is required to work between the wall and the machine, the dust may be advantageously exhausted through a fan placed low down in the wall and securely guarded.

In the case of machines which can not be boxed in it will often be found that the dust is produced at some particular point where it is capable of being locally removed. Thus, for illustration, the committee stated that if the dust is produced as the material is passed through rollers, as in the operation performed by a machine known as a spread board in flax spinning, exhaust ventilation applied close to each roller will remove it completely with a minimum of trouble and expense. In continuation of the discussion the committee pointed out that—

> With regard to all exhaust openings for extraction of dust, etc., it must be clearly borne in mind that in whatever direction the opening may point the air feed is from all round; hence the radius within which a perceptible draft is produced toward the opening is extremely limited. The air current toward an exhaust opening can not be directed except by cumbrous air guides, whereas the current from an inlet can be directed just like the water issuing from a fireman's hose.

It is held that hitherto hardly any advantage has been taken of the latter fact in connection with the removal of dust and fumes, but the committee was confident that many difficult cases can be successfully dealt with by utilizing the momentum of air issuing from an inlet opening, and if compressed air in small tubes is available, fine jets of it directed across any source of dust and fumes toward a large outlet opening would be decidedly effective. It, therefore, suggested as a plan to test the efficiency of any arrangement for the local removal of dust or fumes the simple method of a piece of smoking brown paper or other material held at the place where the dust or fumes are given off.

In the case of dust which may not be discharged into the open air on account of the nuisance or damage which it would cause to the surrounding locality and which must, therefore, be separated from the discharged air, the "Cyclone separator" is often extremely effective, and this separator the committee describes by illustrations in the appendix. The invention requires little space and is easily erected at a point either near to or remote from the fan. It was stated, however, that—

> The dust may also be separated in a settling chamber, taking the form of a room or an outhouse set apart for the purpose. In this case the addition of steam from a jet will often greatly facilitate the precipitation of light dust. Heavier metallic particles can be blown into a tank of water. A common defect in settling chambers is the neglect to provide a sufficient outlet for the spent air, by which means the whole arrangement for exhausting and settling the dust is rendered ineffective.
>
> As it is evident that the circumstances under which fan ventilation needs to be applied vary greatly in different rooms and different processes of manufacture, we would, in conclusion, take this opportunity of pointing out the necessity of carefully considering the special conditions requiring to be dealt with in each individual case, and the desirability of obtaining competent skilled advice in all cases of doubt, or of employing, in the installation of fan ventilation, only such firms as are known to have at their disposal the requisite knowledge and experience.

Finally, in concluding its extremely valuable report, the committee considered the use of respirators, as follows:

> The use of respirators capable of arresting dust is often recommended in connection with factory work as a substitute for efficient removal of dust. Experience has, however, shown that it is extremely difficult to enforce the use of respirators, as they are all more or less uncomfortable and inconvenient, besides being unsightly. It is also very difficult to keep respirators in working order and closely applied to the face. Often enough it is found that most of the air breathed by a person wearing a respirator leaks in between the face and the respirator, and is consequently unfiltered. This is particularly apt to happen after a respirator has been worn sufficiently long for the filtering material to become damp and clogged with moisture. Except, therefore, where dust is definitely dangerous and can not be dealt with by exhaustion, or by using wet processes, or in other ways, we are unable to recommend the use of respirators as an alternative to keeping the air clear of dust.
>
> For the exceptional cases in which it is necessary for men to work in air containing poisonous or otherwise dangerous dust, the mouth and nose may be kept covered by a sheet of fresh cotton wool kept closely applied all round by suitable fastenings passing round the neck. This forms a reliable and efficient respirator, and is commonly used by men who have to perform such work as the removal of arsenic from arsenic flues, or of white lead from lead chambers.
>
> For cases where work has to be done in an atmosphere containing poisonous gases or fumes, a smoke helmet, with air supplied from

outside through a pipe, may be used. The air supply should be not less than 2 cubic feet per minute and may be provided either from a bellows worked by hand or from a mechanically driven air pump or high-pressure centrifugal fan. A self-contained breathing apparatus, such as is used in mines, is less convenient for factory work and more expensive.

The importance and great practical value of preventive measures in efforts to reduce the health-injurious circumstances of different trades has made it seem advisable to make rather extended abstracts from the admirable and thoroughly scientific report of the committee on ventilation of factories and workshops. The conclusions and recommendations of the committee were, however, anticipated by Sir James Crichton-Browne, who, in his address on The Dust Problem, held that—

> In dealing with industrial dust generally the one universal and potent remedy is, of course, ventilation. In contending with certain special kinds of dust special appliances and arrangements are necessary; but for dust, as a whole, our aim should be to intercept and remove it at its point of origin and to insure a bounteous supply of fresh air, and many contrivances for this purpose, more or less efficient, are already in use.

After referring to the then pending report of the departmental committee on the ventilation of factories and workshops, Sir Crichton-Browne summed up his own conclusions in the statement that—

> What is wanted is a code of precise instructions to be placed in the hands of a manufacturer who is required to provide fans, indicating the number, pattern, size, speed, and position of the fans which will most effectively and economically secure the desired result, together with directions as to the number and position of openings into the outer air, and also a judgment on the physiological effects of existing respirators and proposals for the construction of one more convenient and trustworthy and less cumbrous than any yet known.

English opinion is decidedly in favor of a clear statement of the scientific principles that should underlie all methods of factory ventilation and dust removal, but so framed in clear and specific language for the guidance of inspectors that the legal requirements can be carried into effect with the least amount of interference with the industrial methods and conditions of the present day. Sir Crichton-Browne also expressed the hope that the report of the departmental committee would offer suggestions to architects for the construction of factories, since many, if not most of the factories now existing, are so built as to render almost impossible a proper system of ventilation, which should have been a primary consideration in their erection. He was confident in his prediction that rational factory legislation, with special reference to ventilation and dust removal, would greatly tend to reduce the death rate among many different classes of operatives, improve their health, and augment their productive power. He quoted the evidence of factory inspectors and managers who had testified to the improvement in health and the increased vigor of the workers subsequent to the improved methods of ventilation. One leading manufacturer, replying to inquiries of the inspector of cotton-cloth factories, expressed the opinion that "the effect of improved ventilation on the health of the workers has been good. We have had less staying away through sickness than before we had artificial humidity and ventilation in our sheds. The earnings have been more regular, but we do not find that they have increased as much as we expected; but the effect of the change has been advantageous to the manufacturer, the quality of the work being better and more perfect."

Thus upon both humanitarian and economic grounds the effect of scientific ventilation of factories and workshops, and in particular the effective removal of industrial dust, combine to emphasize the need of more or less radical changes in the conditions as they exist at the present time.

The entire subject of the removal of dust and fumes in factories, with special reference to the health-injurious circumstances of dusty trades, has also been presented in an admirable summary account by J. S. Haldane, M. D., F. R. S., in one of the Shaw lectures on "Industrial hygiene," before the Royal Society of Arts, delivered February 28, 1908. Doctor Haldane was one of the most important members of the departmental committee on the ventilation of factories and workshops, and his views, in part, have already been included in the extended account of the report and recommendations of the committee. The following remarks restating his conclusions as to the causes responsible for more or less health-injurious conditions among factory workers and his recommendations as to the methods most likely to bring about a material improvement in those conditions are important and are quoted from his lecture:

> Whether or not any variety of dust is known to cause dangerous effects when habitually inhaled, I think that every kind of dust produced in manufacturing process ought, as far as practicable, to be prevented or removed from the atmosphere in which the work people are present. The reason for this is not only that dusty air is, at the best, unpleasant to breathe, but that when dust is present the clothes, skin, and hair become dirty, untidy, and uncomfortable. This inevitably tends to lower the social status and self-respect of work people if, at any rate, they have to go back to their homes in the same untidy condition. Where dust and dirt can not be avoided the provision of overalls, or of means of washing and changing clothes on leaving work, is extremely desirable.

Of dusts which are definitely harmful, one very important class is that from the disintegration of hard stone or other material. As instances of this we may take the dust from siliceous or other hard stone, which has to be disintegrated in the mining of gold, tin, lead, and other metals, and the dressing of hard stone, or the ground flint dust used in pottery work, or the dust from dry grinding in the metal trades, or the steel dust produced in file cutting and other work.

In many cases the best way of dealing with dust is to prevent its formation altogether. This can be effected by substituting wet for dry processes, and, fortunately, much of the most dangerous dust can be dealt with in this way—in particular the dust from disintegration of hard stone or steel. Thus the use of a jet of water prevents dust formation in rock-drill and other work in tin and ganister mining, special rules to the effect being now in force. It is to be hoped that in all cases where dust from disintegration of hard stone, fire-clay bricks, and similar material is apt to be inhaled, wet methods will also be adopted where possible. The substitution of wet for dry grinding and for dressing of grindstones is another important step in the right direction, and I have little doubt that in many other dusty processes it would be practicable to use wet methods, though, unfortunately, wet processes are quite out of the question in very many cases.

When dust formation can not be avoided, its escape can sometimes be prevented by entirely boxing in the dusty process. Where the dust is itself the product of the process, as in the grinding or breaking up of material, efficient boxing in is an advantage to the process itself as well as to the persons employed in it.

In most cases it is unfortunately not possible to either prevent the formation of dust or to box in the dusty process completely, and the only method available is to draw the dust by means of an air current. There are certain general principles applicable to the removal of dust in this way. In the first place, the dust ought to be removed at, or as near as possible to, the point of origin. The advantages of this are evident, for by this means the dust is prevented from getting into the general atmosphere of the room and being inhaled by those present, as well as settling everywhere. A far smaller volume of air is also sufficient to remove the dust. This is important, not only from the point of view of expense, but because drafts and cold are also prevented. When dust is permitted to get into the general atmosphere of a factory, enormous volumes of air are required to carry it away, which means that equal volumes have to come in from outside, so that warming or prevention of drafts may be quite impracticable. As a good example of the advantage of removing dust locally I may instance a device for removing the dust produced by rollers in a process preparatory to flax-spinning. The dust produced at the rollers is sucked in by small exhaust openings applied close to the rollers. A quite small air current applied in this way is far more effective than one hundred times as great an air current a few feet off would be.

A second general principle is that the air current from the source of dust to the exhaust opening should, as far as possible, envelop the source of dust, and be of sufficient velocity to carry the dust with it in spite of the ordinary slight drafts existing in the room, or produced by the dusty machine. It is unfortunate that in whatever direction an exhaust opening may point, the air entering it is sucked in from all sides. Hence the linear velocity of the draft toward the opening diminishes very rapidly with increasing distance, and at a distance of 2 or 3 feet an exhaust opening, unless very large, will fail to carry off dust efficiently, particularly from a machine which itself causes drafts.

The lecture by Doctor Haldane was fully illustrated to bring its more technical portion within the ready understanding of the layman, and the address should be consulted by all who desire to become thoroughly informed as to the most advanced and qualified opinion regarding the effective and practical removal of dust and fumes in factories and workshops. The remarks and conclusions are decidedly practical, and applicable to American establishments, in which thus far the problem of scientific ventilation and effective dust removal has been almost entirely neglected.

APPENDIX.

TABLE I.—NUMBER OF MALES EMPLOYED IN VARIOUS OCCUPATIONS IN THE UNITED STATES, 1900, BY AGE GROUPS.

[Computed from report of the Bureau of the Census on Occupations, 1900.]

Occupation.	Number of male employees in each age group.						
	15 years or over.	15 to 24 years.	25 to 34 years.	35 to 44 years.	45 to 54 years.	55 to 64 years.	65 years or over.
Tool and cutlery makers	26,997	7,258	8,335	5,811	3,261	1,666	666
Gold and silver workers	19,474	6,493	5,443	3,913	2,009	1,139	477
Brass workers	25,557	8,016	8,531	5,183	2,428	1,034	360
Printers, lithographers, and pressmen	136,923	50,669	44,191	24,210	10,993	5,059	1,801
Engravers	10,628	3,227	3,498	2,124	1,020	509	250
Total—Occupations with exposure to metallic dust	219,579	75,663	69,998	41,246	19,711	9,407	3,554
Marble and stone cutters	54,039	8,579	16.566	14,555	9,075	3,766	1,498
Glass workers	44,396	17,882	13,314	7,625	3,838	1,345	392
Potters	12,856	4,536	3,825	2,545	1,259	483	208
Plasterers	35,506	3,971	9,205	8,839	7,791	3,801	1,899
Paper hangers	21,607	5,486	7,077	4,689	2,821	1,122	412
Total—Occupations with exposure to mineral dust	168,404	40,454	49,987	38,253	24,784	10,517	4,409
Cotton-mill operatives	110,953	53,622	28,129	16,031	8,887	3,346	938
Hosiery and knitting mill operatives	11,372	6,350	2,699	1,355	607	250	111
Paper and pulp makers	26,485	8,747	8,445	5,154	2,764	1,042	333
Cabinetmakers	35,435	4,490	7,940	9,044	6,857	4,144	2,960
Total—Occupations with exposure to vegetable fiber dust	184,245	73,209	47,213	31,584	19,115	8,782	4,342
Hat and cap makers	14,948	4,110	4,655	3,415	1,702	768	298
Silk-mill operatives	20,301	9,022	5,301	3,380	1,563	785	250
Woolen-mill operatives	40,768	15,042	10,056	7,446	4,340	2,189	795
Carpet-factory operatives	10,034	3,180	2,654	1,842	1.182	691	485
Upholsterers	28,434	7,394	8,362	6,013	3,745	1,943	977
Total—Occupations with exposure to animal and mixed fiber dust	114,485	38,748	31,928	22,096	12,532	6,376	2,805
All occupied males—Continental United States	22.802,545	5,933,720	5,933,847	4,704,682	3,250,059	1,856,181	1,063,856

TABLE II.—PER CENT OF MALES EMPLOYED IN EACH AGE GROUP IN VARIOUS OCCUPATIONS IN THE UNITED STATES, 1900.

[Computed from report of the Bureau of the Census on Occupations, 1900.]

Occupation.	Per cent of male employees in each age group.						
	15 years or over.	15 to 24 years.	25 to 34 years.	35 to 44 years.	45 to 54 years.	55 to 64 years.	65 years or over.
Tool and cutlery makers	100.0	26.9	30.9	21.5	12.1	6.2	2.4
Gold and silver workers	100.0	33.3	28.0	20.1	10.3	5.8	2.5
Brass workers	100.0	31.4	33.4	20.3	9.5	4.0	1.4
Printers, lithographers, and pressmen	100.0	37.0	32.3	17.7	8.0	3.7	1.3
Engravers	100.0	30.4	32.9	20.0	9.6	4.8	2.3
Total—Occupations with exposure to metallic dust	100.0	34.4	31.9	18.8	9.0	4.3	1.6
Marble and stone cutters	100.0	15.9	30.6	26.9	16.8	7.0	2.8
Glass workers	100.0	40.3	30.0	17.2	8.6	3.0	0.9
Potters	100.0	35.3	29.7	19.8	9.8	3.8	1.6
Plasterers	100.0	11.2	25.9	24.9	21.9	10.7	5.4
Paper hangers	100.0	25.4	32.7	21.7	13.1	5.2	1.9
Total—Occupations with exposure to mineral dust	100.0	24.0	29.7	22.7	14.7	6.3	2.6
Cotton-mill operatives	100.0	48.3	25.4	14.5	8.0	3.0	0.8
Hosiery and knitting mill operatives	100.0	55.9	23.7	11.9	5.3	2.2	1.0
Paper and pulp makers	100.0	33.0	31.9	19.5	10.4	3.9	1.3
Cabinetmakers	100.0	12.7	22.4	25.5	19.3	11.7	8.4
Total—Occupations with exposure to vegetable fiber dust	100.0	39.7	25.6	17.1	10.4	4.8	2.4
Hat and cap makers	100.0	27.5	31.1	22.9	11.4	5.1	2.0
Silk-mill operatives	100.0	44.4	26.1	17.7	7.7	3.9	1.2
Woolen-mill operatives	100.0	36.9	26.9	18.3	10.6	5.4	1.9
Carpet-factory operatives	100.0	31.7	26.4	18.4	11.8	6.9	4.8
Upholsterers	100.0	26.0	29.4	21.2	13.2	6.8	3.4
Total—Occupations with exposure to animal and mixed fiber dust	100.0	33.8	27.9	19.3	10.9	5.6	2.5
All occupied males—Continental United States	100.0	26.0	26.3	20.6	14.3	8.1	4.7

TABLE III.—NUMBER OF DEATHS IN VARIOUS OCCUPATIONS IN THE REGISTRATION STATES OF THE UNITED STATES, 1900, BY AGE GROUPS.

[From report of the Bureau of the Census on Vital Statistics, 1900.]

Occupation.	Number of deaths due to—					
	All causes in each age group.				Consumption at ages 15 years or over.	Other respiratory diseases at ages 15 years or over.
	15 to 24 years.	25 to 44 years.	45 to 64 years.	65 years or over.		
Compositors, printers, and pressmen	94	333	142	89	237	84
Marble and stone cutters	13	143	155	81	142	53
Glass blowers and workers	17	48	29	13	35	10
Plasterers and whitewashers	9	51	54	32	39	25
Total—Occupations with exposure to mineral dust	39	242	238	126	216	88
Cabinetmakers and upholsterers	19	128	135	164	89	63
Hat and cap makers	17	92	74	45	53	33

TABLE IV.—DEATH RATE PER 1,000 IN VARIOUS OCCUPATIONS IN THE REGISTRATION STATES OF THE UNITED STATES, 1900, BY AGE GROUPS.

[From report of the Bureau of the Census on Vital Statistics, 1900.]

Occupation.	Death rate per 1,000 due to—					
	All causes in each age group.				Consumption at ages 15 years or over.	Other respiratory diseases at ages 15 years or over.
	15 to 24 years.	25 to 44 years.	45 to 64 years.	65 years or over.		
Compositors, printers, and pressmen	5.0	12.3	20.0	108.8	4.4	1.6
Marble and stone cutters	3.4	9.3	24.7	122.9	5.4	2.0
Glass blowers and workers	4.6	10.9	21.8	82.3	3.7	1.0
Plasterers and white washers	7.8	10.7	23.5	88.4	4.5	2.9
Total—Occupations with exposure to mineral dust	4.5	9.9	24.0	106.9	4.9	2.0
Cabinetmakers and upholsterers	4.6	10.5	19.8	109.6	3.6	2.6
Hat and cap makers	5.4	13.1	32.9	173.1	4.2	2.6
All occupied males—Registration States	5.1	8.8	19.9	98.4	2.4	2.0

TABLE V.—NUMBER OF DEATHS FROM ALL CAUSES, FROM CONSUMPTION, AND FROM OTHER RESPIRATORY DISEASES AMONG OCCUPIED MALES IN RHODE ISLAND, COMPARED, 1897 TO 1906.

[From reports of the Rhode Island state board of health.]

Occupation.	Number of deaths due to—				Per cent of deaths due to—		
	All causes.	Consumption.	Other respiratory diseases.	Consumption and other respiratory diseases.	Consumption.	Other respiratory diseases.	Consumption and other respiratory diseases.
Polishers	42	14	20	34	33.3	47.6	80.9
Tool makers	44	9	5	14	20.5	11.4	31.9
Jewelers	557	173	51	224	31.1	9.2	40.3
Brass workers	5	1	....	1	20.0	....	20.0
Printers	81	21	15	36	25.9	18.5	44.4
Compositors	12	3	2	5	25.0	16.7	41.7
Pressmen	5	....	2	2	....	40.0	40.0
Engravers	45	8	4	12	17.8	8.9	26.7
Total—Occupations with exposure to metallic dust	791	229	99	328	29.0	12.5	41.5
Stone cutters and marble workers	125	40	21	61	32.0	16.8	48.8
Plasterers	25	5	4	9	20.0	16.0	36.0
Paper hangers	14	3	3	6	21.4	21.4	42.8
Molders	157	31	25	56	19.7	15.9	35.6
Total—Occupations with exposure to mineral dust	321	79	53	132	24.6	16.5	41.1
Operatives	798	218	73	291	27.3	9.1	36.4
Spinners	71	18	5	23	25.4	7.0	32.4
Weavers	259	67	30	97	25.9	11.6	37.5
Knitters	8	5	....	5	62.5	....	62.5
Cabinetmakers	50	12	9	21	24.0	18.0	42.0
Wood turners and finishers	38	5	10	15	13.2	26.3	39.5
Total—Occupations with exposure to vegetable fiber dust	1,224	325	127	452	26.6	10.4	37.0
Wool sorters	37	5	5	10	13.5	13.5	27.0
Upholsterers	25	6	3	9	24.0	12.0	36.0
Total—Occupations with exposure to animal and mixed fiber dust	62	11	8	19	17.7	12.9	30.6
All occupied males—State of Rhode Island	19,314	3,429	2,420	5,849	17.8	12.5	30.3

TABLE VI.—YEARS OF LIFE LIVED BY OCCUPIED MALES IN CERTAIN OCCUPATIONS, IN ENGLAND AND WALES DURING THE YEARS 1900 TO 1902, BY AGE GROUPS.(a)

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths and Marriages in England and Wales.]

Occupation.	Years of life lived by males in each age group during 1900 to 1902. (a)						
	15 to 19 years.	20 to 24 years.	25 to 34 years.	35 to 44 years.	45 to 54 years.	55 to 64 years.	65 years or over.
Tool and instrument makers	17,721	15,942	29,904	24,387	18,522	11,415	5,067
Brass workers	28,815	23,010	33,078	21,420	13,443	6,585	2,256
Printers	56,076	46,080	78,153	48,465	28,542	13,752	4,383
Total—Occupations with exposure to metallic dust	102,612	85,032	141,135	94,272	60,507	31,752	11,706
Glass workers	17,700	11,589	20,166	13,167	9,030	4,374	1,290
Potters	19,455	17,112	29,463	20,043	12,894	6,408	2,055
Paper hangers and whitewashers	19,704	21,786	29,490	27,162	20,181	10,236	3,921
Lithographers	5,163	4,848	8,898	6,066	3,510	1,848	693
Total—Occupations with exposure to mineral dust	62,022	55,335	88,017	66,438	45,615	22,866	7,959
Cotton manufacture	107,298	82,881	135,507	98,739	59,079	27,948	7,965
Hosiery-mill employees	4,989	3,825	8,541	8,049	6,150	4,329	3,807
Lace makers	6,201	4,461	8,790	8,358	4,281	2,703	1,359
Cordage makers	4,095	1,914	3,093	2,820	2,532	2,124	1,332
Paper makers	9,237	6,984	10,749	7,512	5,070	2,691	981
Cabinetmakers	54,741	46,614	72,924	55,869	39,957	22,842	10,194
Wood turners	15,975	13,008	22,161	19,254	15,774	10,806	4,428
Total—Occupations with exposure to vegetable fiber dust	202,536	159,687	261,765	200,601	132,843	73,443	30,066
Furriers	2,151	2,265	4,341	3,795	2,847	1,365	510
Hatters	6,561	6,627	12,981	9,006	6,306	3,225	1,257
Silk workers	4,350	2,751	5,829	5,373	3,798	3,249	2,994
Woolen and worsted mill employees	39,249	30,222	56,322	44,046	33,132	20,268	8,610
Carpet and rug makers	3,114	2,313	4,947	4,134	3,060	1,650	1,002
Total—Occupations with exposure to animal and mixed fiber dust	55,425	44,178	84,420	66,354	49,143	29,757	14,373

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a The years of life as used in this table means three times the number of occupied males enumerated at the census of 1901.

TABLE VII.—MORTALITY DUE TO ALL CAUSES AMONG OCCUPIED MALES IN CERTAIN OCCUPATIONS IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Occupation.	Deaths due to all causes in each age group.						
	15 to 19 years.	20 to 24 years.	25 to 34 years.	35 to 44 years.	45 to 54 years.	55 to 64 years.	65 years or over.
Tool and instrument makers	37	53	189	333	481	480	510
Brass workers	64	118	194	274	281	241	189
Printers	179	278	505	494	507	423	384
Total—Occupations with exposure to metallic dust	280	449	888	1,101	1,269	1,144	1,083
Glass workers	57	59	136	173	218	183	154
Potters	51	63	155	291	408	347	243
Paper hangers and whitewashers	30	75	120	313	387	333	283
Lithographers	8	26	50	51	70	57	57
Total—Occupations with exposure to mineral dust	146	223	461	828	1,083	920	737
Cotton manufacture	288	358	742	949	1,209	1,150	1,014
Hosiery-mill employees	5	22	46	54	99	152	503
Lace makers	16	12	59	70	50	88	119
Cordage makers	9	11	20	21	33	69	141
Paper makers	32	28	54	50	56	71	93
Cabinetmakers	143	174	379	550	693	700	846
Wood turners	31	58	138	225	394	375	411
Total—Occupations with exposure to vegetable fiber dust	524	663	1,438	1,919	2,534	2,605	3,127
Furriers	8	10	37	49	57	70	55
Hatters	19	41	87	103	125	116	130
Silk workers	10	9	24	46	68	117	322
Woolen and worsted mill employees	86	152	292	392	568	752	1,110
Carpet and rug makers	9	12	29	39	56	56	117
Total—Occupations with exposure to animal and mixed fiber dust	132	224	469	629	874	1,111	1,734

TABLE VIII.—MORTALITY DUE TO CONSUMPTION AMONG OCCUPIED MALES IN CERTAIN OCCUPATIONS IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Occupation.	Deaths due to consumption in each age group.						
	15 to 19 years.	20 to 24 years.	25 to 34 years.	35 to 44 years.	45 to 54 years.	55 to 64 years.	65 years or over.
Tool and instrument makers	3	25	88	144	132	60	10
Brass workers	14	50	97	97	62	17	1
Printers	58	157	285	235	122	47	7
Total—Occupations with exposure to metallic dust	75	232	470	476	316	124	18
Glass workers	10	21	58	60	44	13	....
Potters	12	23	59	76	92	28	2
Paper hangers and whitewashers	8	23	36	108	73	41	6
Lithographers	4	13	24	19	15	8	1
Total—Occupations with exposure to mineral dust	34	80	177	263	224	90	9
Cotton manufacture	88	137	273	285	216	77	17
Hosiery-mill employees	3	9	21	20	26	15	3
Lace makers	7	5	25	20	11	6	1
Cordage makers	1	4	8	7	3	8	2
Paper makers	5	9	21	16	9	5	1
Cabinetmakers	38	77	159	212	153	62	19
Wood turners	10	20	64	73	87	32	6
Total—Occupations with exposure to vegetable fiber dust	152	261	571	633	505	205	49
Furriers	....	4	15	18	11	10	3
Hatters	4	23	48	37	30	7	....
Silk workers	1	5	14	11	15	12	6
Woolen and worsted mill employees	27	72	102	99	94	46	16
Carpet and rug makers	2	6	7	13	9	4	1
Total—Occupations with exposure to animal and mixed fiber dust	34	110	186	178	159	79	26

TABLE IX.—MORTALITY DUE TO OTHER DISEASES OF THE RESPIRATORY SYSTEM AMONG OCCUPIED MALES IN CERTAIN OCCUPATIONS IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Occupation.	Deaths due to other respiratory diseases in each age group.						
	15 to 19 years.	20 to 24 years.	25 to 34 years.	35 to 44 years.	45 to 54 years.	55 to 64 years.	65 years or over.
Tool and instrument makers	4	9	34	49	100	119	129
Brass workers	7	12	20	44	53	62	43
Printers	20	17	43	60	62	71	91
Total—Occupations with exposure to metallic dust	31	38	97	153	215	252	263
Glass workers	5	7	20	32	52	47	37
Potters	9	10	19	66	139	148	72
Paper hangers and whitewashers	3	10	23	37	79	91	67
Lithographers	....	1	7	6	6	8	19
Total—Occupations with exposure to mineral dust	17	28	69	141	276	294	195
Cotton manufacture	27	50	110	149	247	274	227
Hosiery-mill employees	1	1	6	6	18	26	103
Lace makers	....	2	3	4	7	21	24
Cordage makers	....	3	3	2	8	19	39
Paper makers	3	3	7	9	14	13	16
Cabinetmakers	17	20	47	72	118	166	183
Wood turners	5	8	16	51	68	93	110
Total—Occupations with exposure to vegetable fiber dust	53	87	192	293	480	612	702
Furriers	2	3	4	9	5	16	8
Hatters	....	2	10	12	31	35	30
Silk workers	3	....	....	7	9	12	75
Woolen and worsted mill employees	12	7	42	64	102	131	219
Carpet and rug makers	1	1	5	4	7	15	29
Total—Occupations with exposure to animal and mixed fiber dust	18	13	61	96	154	209	361

TABLE X.—DEATH RATE PER 1,000 DUE TO ALL CAUSES AMONG OCCUPIED MALES IN CERTAIN OCCUPATIONS IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Occupation.	Death rate per 1,000 due to all causes in each age group.						
	15 to 19 years.	20 to 24 years.	25 to 34 years.	35 to 44 years.	45 to 54 years.	55 to 64 years.	65 years or over.
Tool and instrument makers	2.09	3.32	6.32	13.65	25.97	42.05	100.65
Brass workers	2.22	5.13	5.86	12.79	20.90	36.60	83.78
Printers	3.19	6.03	6.46	10.19	17.76	30.76	87.61
Total—Occupations with exposure to metallic dust	2.73	5.28	6.29	11.68	20.97	36.03	92.52
Glass workers	3.22	5.09	6.74	13.14	24.14	41.84	119.38
Potters	2.62	3.68	5.26	14.52	31.64	54.15	118.25
Paper hangers and whitewashers	1.52	3.44	4.07	11.52	19.18	32.53	72.18
Lithographers	1.55	5.36	5.62	8.41	19.94	30.84	82.25
Total—Occupations with exposure to mineral dust	2.35	4.02	5.24	12.46	23.74	40.23	92.00
Cotton manufacture	2.68	4.32	5.48	9.61	20.46	41.15	127.31
Hosiery-mill employees	1.00	5.75	5.39	6.71	16.10	35.11	132.12
Lace makers	2.58	2.69	6.71	8.38	11.68	32.56	87.56
Cordage makers	2.20	5.75	6.47	7.45	13.03	32.49	105.86
Paper makers	3.46	4.01	5.02	6.66	11.05	26.38	94.80
Cabinetmakers	2.61	3.73	5.20	9.84	17.34	30.65	82.99
Wood turners	1.94	4.46	6.23	11.69	24.98	34.70	92.82
Total—Occupations with exposure to vegetable fiber dust	2.59	4.15	5.49	9.57	19.08	35.47	104.00
Furriers	3.72	4.42	8.52	12.91	20.02	51.28	107.84
Hatters	2.90	6.19	6.70	11.44	19.82	35.97	103.42
Silk workers	2.30	3.27	4.12	8.56	17.90	36.01	107.55
Woolen and worsted mill employees	2.19	5.03	5.18	8.90	17.14	37.10	128.92
Carpet and rug makers	2.89	5.19	5.86	9.43	18.30	33.94	116.77
Total—Occupations with exposure to animal and mixed fiber dust	2.38	5.07	5.56	9.48	17.78	37.33	120.64
All occupied males—England and Wales	2.44	4.41	6.01	10.22	17.73	31.01	88.39

TABLE XI.—DEATH RATE PER 1,000 DUE TO CONSUMPTION AMONG OCCUPIED MALES IN CERTAIN OCCUPATIONS IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Occupation.	Death rate per 1,000 due to consumption in each age group.						
	15 to 19 years.	20 to 24 years.	25 to 34 years.	35 to 44 years.	45 to 54 years.	55 to 64 years.	65 years or over.
Tool and instrument makers	0. 17	1. 57	2. 94	5. 90	7. 13	5. 26	1. 97
Brass workers	. 49	2. 17	2. 93	4. 53	4. 61	2. 58	. 44
Printers	1. 03	3. 41	3. 65	4. 85	4. 27	3. 42	1. 60
Total—Occupations with exposure to metallic dust	. 73	2. 73	3. 33	5. 05	5. 22	3. 91	1. 54
Glass workers	. 56	1. 81	2. 88	4. 56	4. 87	2. 97	....
Potters	. 62	1. 34	2. 00	3. 79	7. 14	4. 37	. 97
Paper hangers and whitewashers	. 41	1. 06	1. 22	3. 98	3. 62	4. 01	1. 53
Lithographers	. 77	2. 68	2. 70	3. 13	4. 27	4. 33	1. 44
Total—Occupations with exposure to mineral dust	. 55	1. 44	2. 01	3. 96	4. 91	3. 94	1. 13
Cotton manufacture	. 82	1. 65	2. 01	2. 89	3. 66	2. 76	2. 13
Hosiery-mill employees	. 60	2. 35	2. 46	2. 48	4. 23	3. 47	. 79
Lace makers	1. 13	1. 12	2. 84	2. 39	2. 57	2. 22	. 74
Cordage makers	. 24	2. 09	2. 59	2. 48	1. 18	3. 77	1. 50
Paper makers	. 54	1. 29	1. 95	2. 13	1. 78	1. 86	1. 02
Cabinetmakers	. 69	1. 65	2. 18	3. 79	3. 83	2. 71	1. 86
Wood turners	. 63	1. 54	2. 89	3. 79	5. 52	2. 96	1. 36
Total—Occupations with exposure to vegetable fiber dust	. 75	1. 63	2. 18	3. 16	3. 80	2. 79	1. 63
Furriers	....	1. 77	3. 46	4. 74	3. 86	7. 33	5. 88
Hatters	. 61	3. 47	3. 70	4. 11	4. 76	2. 17	....
Silk workers	. 23	1. 82	2. 40	2. 05	3. 95	3. 69	2. 00
Woolen and worsted mill employees	. 69	2. 38	1. 81	2. 25	2. 84	2. 27	1. 86
Carpet and rug makers	. 64	2. 59	1. 41	3. 14	2. 94	2. 42	1. 00
Total—Occupations with exposure to animal and mixed fiber dust	. 61	2. 49	2. 20	2. 68	3. 24	2. 65	1. 81
All occupied males—England and Wales	. 54	1. 55	2. 03	2. 74	3. 04	2. 16	1. 11

TABLE XII.—DEATH RATE PER 1,000 DUE TO OTHER DISEASES OF THE RESPIRATORY SYSTEM AMONG OCCUPIED MALES IN CERTAIN OCCUPATIONS IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[From Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Occupation.	Death rate per 1,000 due to other respiratory diseases in each age group.						
	15 to 19 years.	20 to 24 years.	25 to 34 years.	35 to 44 years.	45 to 54 years.	55 to 64 years.	65 years or over.
Tool and instrument makers	0.23	0.56	1.14	2.01	5.40	10.42	25.46
Brass workers	.24	.52	.60	2.05	3.94	9.42	19.06
Printers	.36	.37	.55	1.24	2.17	5.16	20.76
Total—Occupations with exposure to metallic dust	.30	.45	.69	1.62	3.55	7.94	22.46
Glass workers	.28	.60	.99	2.43	5.76	10.75	28.68
Potters	.46	.58	.64	3.29	10.78	23.10	35.04
Paper hangers and whitewashers	.15	.46	.78	1.36	3.91	8.89	17.09
Lithographers	....	.21	.79	.99	1.71	4.33	27.42
Total—Occupations with exposure to mineral dust	.27	.50	78	2.12	6.05	12.86	24.50
Cotton manufacture	.25	.60	.81	1.51	4.18	9.80	28.50
Hosiery-mill employees	.20	.26	.70	.75	2.93	6.01	27.06
Lace makers	....	.45	.34	.48	1.64	7.77	17.66
Cordage makers	....	1.57	.97	.71	3.16	8.95	29.28
Paper makers	.32	.43	.65	1.20	2.76	4.83	16.31
Cabinetmakers	.31	.43	.64	1.29	2.95	7.27	17.95
Wood turners	.31	.62	.72	2.65	4.31	8.61	24.84
Total—Occupations with exposure to vegetable fiber dust	.26	.54	.73	1.46	3.61	8.33	23.35
Furriers	.93	1.32	.92	2.37	1.76	11.72	15.69
Hatters	....	.30	.77	1.33	4.92	10.85	23.87
Silk workers	.69	....	....	1.30	2.37	3.69	25.05
Woolen and worsted mill employees	.31	.23	.75	1.45	3.08	6.46	25.44
Carpet and rug makers	.32	.43	1.01	.97	2.29	9.09	28.94
Total—Occupations with exposure to animal and mixed fiber dust	.32	.29	.72	1.45	3.13	7.02	25.12
All occupied males—England and Wales	.24	.48	.77	1.66	3.32	6.54	17.77

TABLE XIII.—DEATHS DUE TO ALL CAUSES AMONG OCCUPIED MALES IN CERTAIN OCCUPATIONS IN THE UNITED STATES, 1897 TO 1906, BY AGE GROUPS.

[From the experience of an industrial insurance company.]

Occupation.	Deaths due to all causes in each age group.						
	15 years or over.	15 to 24 years.	25 to 34 years.	35 to 44 years.	45 to 54 years.	55 to 64 years.	65 years or over.
Grinders	128	7	24	38	30	20	9
Polishers	279	48	75	68	48	19	21
Tool and instrument makers	303	40	59	68	56	32	48
Jewelers	403	60	74	50	59	77	83
Gold-leaf makers	25	2	8	4	3	2	6
Brass workers	414	66	112	91	58	54	33
Printers	1,590	344	439	346	211	142	108
Compositors	168	21	54	32	19	33	9
Engravers	192	31	47	42	34	19	19
Total—Occupations with exposure to metallic dust	3,502	619	892	739	518	398	336
Stone workers	858	21	114	172	232	199	120
Marble workers	200	3	30	40	46	50	31
Glass blowers	282	24	78	59	55	26	40
Glass cutters	116	26	30	27	20	8	5
Potters	384	46	68	84	78	72	36
Cement workers	88	10	12	19	15	19	13
Plasterers	577	25	78	107	127	121	119
Paper hangers	319	33	96	74	55	34	27
Foundrymen and molders	1,397	122	228	300	292	239	216
Core makers	162	66	42	25	9	9	11
Lithographers	160	37	45	29	21	18	10
Total—Occupations with exposure to mineral dust	4,543	413	821	936	950	795	628
Spinners	189	28	38	36	27	37	23
Weavers	915	108	174	155	144	137	197
Hosiery and knitting mill employees	65	23	22	7	9	3	1
Rope makers	109	12	18	17	18	24	20
Paper makers	115	13	28	18	15	23	18
Cabinetmakers	817	39	61	82	136	197	302
Wood turners	127	10	8	17	24	33	35
Wood carvers	123	11	20	23	31	21	17
Total—Occupations with exposure to vegetable fiber dust	2,460	244	369	355	404	475	613
Furriers and taxidermists	105	3	18	30	13	24	17
Hatters	832	78	175	185	127	135	132
Silk-mill employees	295	82	61	55	31	37	29
Woolen and worsted mill employees	106	20	16	14	19	24	13
Carpet and rug makers	155	17	22	17	24	34	41
Upholsterers	381	39	65	79	73	62	63
Mattress makers	41	9	7	11	5	8	1
Total—Occupations with exposure to animal and mixed fiber dust	1,915	248	364	391	292	324	296

TABLE XIV.—DEATHS DUE TO CONSUMPTION AMONG OCCUPIED MALES IN CERTAIN OCCUPATIONS IN THE UNITED STATES, 1897 TO 1906, BY AGE GROUPS.

[From the experience of an industrial insurance company.]

Occupation.	Deaths due to consumption in each age group.						
	15 years or over.	15 to 24 years.	25 to 34 years.	35 to 44 years.	45 to 54 years.	55 to 64 years.	65 years or over.
Grinders	63	4	17	24	12	5	1
Polishers	108	22	42	29	11	4	
Tool and instrument makers	101	13	35	24	21	4	4
Jewelers	113	24	44	22	13	7	3
Gold-leaf makers	7	1	4	2			
Brass workers	161	39	56	41	14	11	
Printers	613	167	247	140	42	13	4
Compositors	59	6	36	12	3	1	1
Engravers	67	12	29	19	5	2	
Total—Occupations with exposure to metallic dust	1,292	288	510	313	121	47	13
Stone workers	302	10	60	82	91	52	7
Marble workers	56		15	16	16	7	2
Glass blowers	85	11	44	15	11	1	3
Glass cutters	40	7	14	11	5	1	2
Potters	127	11	36	37	22	14	7
Cement workers	17	1	3	4	6	3	
Plasterers	136	7	35	38	35	16	5
Paper hangers	107	14	47	33	8	4	1
Foundrymen and molders	311	29	92	82	65	27	16
Core makers	48	20	17	9	1	1	
Lithographers	70	21	28	13	5	3	
Total—Occupations with exposure to mineral dust	1,299	131	391	340	265	129	43
Spinners	56	13	19	16	7	1	
Weavers	254	43	93	59	37	15	7
Hosiery and knitting mill employees	24	5	15	2	2		
Rope makers	28	6	9	7	6		
Paper makers	34	6	15	7	2	3	1
Cabinetmakers	162	14	34	40	31	29	14
Wood turners	25	7	5	3	4	5	1
Wood carvers	27	3	9	9	5	1	
Total—Occupations with exposure to vegetable fiber dust	610	97	199	143	94	54	23
Furriers and taxidermists	34	1	7	19	4	2	1
Hatters	278	42	97	84	34	20	1
Silk-mill employees	106	28	32	33	7	4	2
Woolen and worsted mill employees	26	7	7	5	4	3	
Carpet and rug makers	37	9	10	6	5	4	3
Upholsterers	118	15	38	38	18	3	6
Mattress makers	16	4	3	4	2	3	
Total—Occupations with exposure to animal and mixed fiber dust	615	106	194	189	74	39	13

TABLE XV.—PER CENT OF DEATHS DUE TO CONSUMPTION AMONG OCCUPIED MALES IN CERTAIN OCCUPATIONS, 1897 TO 1906, BY AGE GROUPS.

[From the experience of an industrial insurance company.]

Occupation.	Per cent of deaths due to consumption in each age group.						
	15 years or over.	15 to 24 years.	25 to 34 years.	35 to 44 years.	45 to 54 years.	55 to 64 years.	65 years or over.
Grinders	49.2	57.1	70.8	63.2	40.0	25.0	11.1
Polishers	38.7	45.8	56.0	42.6	22.9	21.1	....
Tool and instrument makers	33.3	32.5	59.3	35.3	37.5	12.5	8.3
Jewelers	28.0	40.0	59.5	44.0	22.0	9.1	3.6
Gold-leaf makers	28.0	50.0	50.0	50.0	....	....	....
Brass workers	38.9	59.1	50.0	45.1	24.1	20.4	....
Printers	38.6	48.6	56.3	40.5	19.9	9.2	3.7
Compositors	35.1	28.6	66.7	37.5	15.8	3.0	11.1
Engravers	34.9	38.7	61.7	45.2	14.7	10.5	....
Total—Occupations with exposure to metallic dust	36.9	46.5	57.2	42.4	23.4	11.8	3.9
Stone workers	35.2	47.6	52.6	47.7	39.2	26.1	5.8
Marble workers	28.0	....	50.0	40.0	34.8	14.0	6.5
Glass blowers	30.1	45.8	56.4	25.4	20.0	3.8	7.5
Glass cutters	34.5	26.9	46.7	40.7	25.0	12.5	40.0
Potters	33.1	23.9	52.9	44.0	28.2	19.4	19.4
Cement workers	19.3	10.0	25.0	21.1	40.0	15.8	....
Plasterers	23.6	28.0	44.9	35.5	27.6	13.2	4.2
Paper hangers	33.5	42.4	49.0	44.6	14.5	11.8	3.7
Foundrymen and molders	22.3	23.8	40.4	27.3	22.3	11.3	7.4
Core makers	29.6	30.3	40.5	36.0	11.1	11.1	....
Lithographers	43.8	56.8	62.2	44.8	23.8	16.7	....
Total—Occupations with exposure to mineral dust	28.6	31.7	47.6	36.3	27.9	16.2	6.8
Spinners	29.6	46.4	50.0	44.4	25.9	2.7	....
Weavers	27.8	39.8	53.4	38.1	25.7	10.9	3.6
Hosiery and knitting mill employees	36.9	21.7	68.2	28.6	22.2	....	....
Rope makers	25.7	50.0	50.0	41.2	33.3	....	....
Paper makers	29.6	46.2	53.6	38.9	13.3	13.0	5.6
Cabinetmakers	19.8	35.9	55.7	48.8	22.8	14.7	4.6
Wood turners	19.7	70.0	62.5	17.6	16.7	15.2	2.9
Wood carvers	22.0	27.3	45.0	39.1	16.1	4.8	....
Total—Occupations with exposure to vegetable fiber dust	24.8	39.8	53.9	40.3	23.3	11.4	3.8
Furriers and taxidermists	32.4	33.3	38.9	63.3	30.8	8.3	5.9
Hatters	33.4	53.8	55.4	45.4	26.7	14.8	0.8
Silkmill employees	35.9	34.1	52.5	60.0	22.6	10.8	6.9
Woolen and worsted mill employees	24.5	35.0	43.8	35.7	21.1	12.5	....
Carpet and rug makers	23.9	52.9	45.5	35.3	20.8	11.8	7.3
Upholsterers	31.0	38.5	58.5	48.1	24.7	4.8	9.5
Mattress makers	39.0	44.4	42.9	36.4	40.0	37.5	....
Total—Occupations with exposure to animal and mixed fiber dust	32.1	42.7	53.3	48.3	25.3	12.0	4.4

TABLE XVI.—NUMBER AND PER CENT OF DEATHS DUE TO OTHER DISEASES OF THE RESPIRATORY SYSTEM AMONG OCCUPIED MALES IN CERTAIN OCCUPATIONS, 1897 TO 1906.

[From the experience of an industrial insurance company.]

Occupation.	Deaths due to respiratory diseases other than consumption.									
	Number due to—					Per cent of deaths from all causes.				
	All respiratory diseases.	Asthma.	Bronchitis.	Pneumonia.	Other respiratory diseases.	All respiratory diseases.	Asthma.	Bronchitis.	Pneumonia.	Other respiratory diseases.
Grinders	22	3	2	15	2	17.2	2.3	1.6	11.7	1.6
Polishers	35	2	3	25	5	12.6	.7	1.1	9.0	1.8
Tool and instrument makers	39	4	5	25	5	12.9	1.3	1.7	8.2	1.7
Jewelers	49	2	8	37	2	12.2	.5	2.0	9.2	.5
Gold leaf makers	5	....	....	3	2	20.0	....	....	12.0	8.0
Brass workers	51	2	1	36	12	12.3	.5	.2	8.7	2.9
Printers	221	9	19	169	24	13.9	.6	1.2	10.6	1.5
Compositors	25	1	....	19	5	14.9	.6	....	11.3	3.0
Engravers	22	1	....	18	3	11.5	.5	....	9.4	1.6
Total — Occupations with exposure to metallic dust	469	24	38	347	60	13.4	.7	1.1	9.9	1.7
Stone workers	162	13	30	95	24	18.9	1.5	3.5	11.1	2.8
Marble workers	36	3	4	26	3	18.0	1.5	2.0	13.0	1.5
Glass blowers	26	1	2	17	6	9.2	.4	.7	6.0	2.1
Glass cutters	15	1	....	12	2	12.9	.9	....	10.3	1.7
Potters	57	18	12	21	6	14.9	4.7	3.1	5.5	1.6
Cement workers	8	1	1	5	1	9.0	1.1	1.1	5.7	1.1
Plasterers	93	5	14	67	7	16.1	.9	2.4	11.6	1.2
Paper hangers	38	....	3	30	5	11.9	....	.9	9.4	1.6
Foundrymen and molders	277	14	21	211	31	19.8	1.0	1.5	15.1	2.2
Core makers	28	....	1	24	3	17.3	....	.6	14.8	1.9
Lithographers	22	....	3	18	1	13.8	....	1.9	11.3	.6
Total — Occupations with exposure to mineral dust	762	56	91	526	89	16.8	1.2	2.0	11.6	2.0
Spinners	28	4	2	17	5	14.8	2.1	1.1	9.0	2.6
Weavers	119	10	18	78	13	13.0	1.1	2.0	8.5	1.4
Hosiery and knitting mill employees	3	....	....	1	2	4.6	....	....	1.5	3.1
Rope makers	9	1	2	6	....	8.2	.9	1.8	5.5	....
Paper makers	10	....	1	9	....	8.7	....	.9	7.8	....
Cabinetmakers	120	14	14	75	17	14.7	1.7	1.7	9.2	2.1
Wood turners	21	3	2	11	5	16.5	2.4	1.6	8.6	3.9
Wood carvers	16	2	2	9	3	13.0	1.6	1.6	7.3	2.5
Total — Occupations with exposure to vegetable fiber dust	326	34	41	206	45	13.3	1.4	1.7	8.4	1.8
Furriers and taxidermists	17	....	5	9	3	16.2	....	4.8	8.6	2.8
Hatters	97	4	12	71	10	11.7	.5	1.5	8.5	1.2
Silk-mill employees	33	2	3	21	7	11.2	.7	1.0	7.1	2.4
Woolen and worsted mill employees	17	5	2	8	2	16.0	4.7	1.9	7.5	1.9
Carpet and rug makers	26	3	3	16	4	16.7	1.9	1.9	10.3	2.6
Upholsterers	46	3	2	33	8	12.1	.8	.5	8.7	2.1
Mattress makers	6	....	....	6	....	14.6	....	....	14.6	....
Total — Occupations with exposure to animal and mixed fiber dust	242	17	27	164	34	12.7	.9	1.4	8.6	1.8

TABLE **XVII.**—DEATHS DUE TO ALL CAUSES, TO CONSUMPTION, AND TO OTHER RESPIRATORY DISEASES AMONG MALES IN THE REGISTRATION AREA OF THE UNITED STATES, 1900 TO 1906, BY AGE GROUPS.

[From reports of the Bureau of the Census on Mortality.]

Age at death.	Deaths due to all causes.	Deaths due to consumption.		Deaths due to other respiratory diseases.	
		Number.	Per cent of deaths due to all causes.	Number.	Per cent of deaths due to all causes.
15 to 24 years	134,700	37,495	27.8	13,010	9.7
25 to 34 years	186,530	58,424	31.3	20,298	10.9
35 to 44 years	205,930	48,500	23.6	25,655	12.5
45 to 54 years	205,497	30,781	15.0	25,869	12.6
55 to 64 years	218,151	17,707	8.1	26,575	12.2
65 years or over	435,228	11,949	2.7	50,603	11.6
Total	1,386,036	204,856	14.8	162,010	11.7

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CHARITY RELIEF AND WAGE EARNINGS.

BY S. E. FORMAN.

INTRODUCTION.

This article is a study of the relief given by the Associated Charities in the city of Washington, D. C., in 1905. The investigation deals with the cases of several thousand persons who sought relief at the door of charity. The aim of the study is to determine the relation which exists between the charity relief and the earnings of the recipients, and to discover to what extent this distress was due to low wages or to a lack of employment, and to what extent other causes figured in the distress.

The result of the study will be better understood if consideration is first given to the aims and methods of the Associated Charities. Those aims and methods have been recently formulated as follows:

1. To bring about the adequate treatment of each needy individual or family upon the basis of an adequate understanding of the needs and resources.

2. To promote cooperation between all the philanthropic forces, the public and private charities, the churches, municipal authorities, and benevolent individuals of the community, in order that the efficiency of all may be increased and each enabled to do its own best work in its own best way.

3. To obtain and administer material aid where necessary, endeavoring to secure the assistance from appropriate organizations and individuals, and not to interfere with or unnecessarily decrease in any case the responsibility of agencies or persons from whom the relief should be derived.

4. To enlist, organize, and direct volunteer workers, including division conference members, friendly visitors, savings collectors, conductors of outing parties, office assistants, and helpers in other lines.

5. To prevent pauperism and dependence, to discourage begging and the giving of alms without adequate investigation, to expose deliberate imposture or fraud, to not merely palliate distress but to relieve it permanently, and in every case to develop all the possibilities of self-help.

6. To improve home life, develop character, and elevate the standards of life, to prevent children from growing up as paupers, and to aid needy families in securing for ruptured and deformed children such treatment as will prevent permanent disabilities and dependence.

U. S. DEPARTMENT OF LABOR
BUREAU OF LABOR STATISTICS
ROYAL MEEKER, Commissioner

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MORTALITY FROM RESPIRATORY DISEASES IN DUSTY TRADES

(INORGANIC DUSTS)

BY FREDERICK L. HOFFMAN

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MORTALITY FROM RESPIRATORY DISEASES IN DUSTY TRADES.

CHAPTER I.—GENERAL INTRODUCTION.

The administrative control of tuberculosis in American States and cities has heretofore been concentrated chiefly upon legislative enactments, and their enforcement, for the registration of existing cases, the voluntary or compulsory segregation and detention of tuberculosis patients, the establishment of Federal, State, county, and municipal tuberculosis sanatoriums, and the enforcement of sanitary ordinances against indiscriminate expectoration in public places. Some progress has been made in the direction of labor legislation aiming at the control of tuberculosis in industry, principally in the so-called dusty trades, but the results have been far from satisfactory, chiefly because of an inadequate realization of the seriousness of the situation. The statistical evidence that certain trades or occupations are distinctly more unfavorable to health and longevity than others is so entirely conclusive that no additional proof seems to be necessary to reemphasize the earlier conviction that the State regulation of industry with special reference to the dusty trades and tuberculosis is a National and State labor problem of the first order in practical importance, yet there continues to prevail a lamentable degree of apathy and indifference to the urgency of necessary changes and reforms.[1]

THE DECLINE OF TUBERCULOSIS.

The mortality from tuberculosis, it is true, has gradually declined from an average rate of 32 per 10,000 for large American cities for the five years ending with 1884, to 16.1 per 10,000 for the five years ending with 1914. This reduction in the death rate has, however, only to a limited degree affected the persons most seriously concerned—the workmen and workwomen employed in the so-called dusty trades. On the basis of a conservative estimate it appears that of the 44,130,000 American wage earners of both sexes, approximately 4,000,000, or 9.06 per cent, work under conditions more or less detrimental to health and life on account of atmospheric pollution or the relatively excessive presence of atmospheric impurities predisposing to, or accelerating the relative frequency of, tuberculous and nontuberculous respiratory diseases.

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[1] Especially suggestive as regards modern efforts in the direction of administrative control of the dusty trades are "The Labor Law and the Industrial Code," of the New York State Department of Labor, Albany, 1916; "The Sanitary and Engineering Industrial Standards," published by the Department of Labor of the State of New Jersey, 1916; Special Bulletin No. 82 of the Department of Labor of the State of New York on "Hoods for Removing Dust, Fumes, and Gases," and the extended discussion of dusty occupations in the annual report of the Department of Labor of the State of New Jersey, for 1916, Trenton, N. J., 1917.

WAGE EARNERS IN DUSTY TRADES.

Table 1 presents the details of this estimate for the seven recognized branches of industry more or less exposing to health-injurious dust and fumes.

TABLE 1.—AMERICAN WAGE EARNERS EMPLOYED IN DUSTY INDUSTRIES, TRADES, AND OCCUPATIONS.

[Compiled from Report of Bureau of the Census on Occupation Statistics, 1910. For occupations included, see pp. 46–50.]

Trade group.	Males.		Females.	
	Number.	Per cent.	Number.	Per cent.
1. Metallic dust	258,454	7.9	33,255	4.9
2. Mineral dust	514,693	15.8	15,332	2.3
3. Mineral industries	844,897	25.9	550	.1
4. Vegetable fiber dust	336,323	10.3	296,135	44.0
5. Animal and mixed fiber dust	183,937	5.6	149,262	22.2
6. Organic dust	531,911	16.3	177,545	26.4
7. Mixed organic and inorganic (public) dusts	594,285	18.2	1,399	.2
Total	3,264,500	100.0	673,478	100.0

This formidable array of employments with exposure, more or less, to health-injurious conditions, attributable chiefly to the single factor of dust in its varied forms, suggests the practical importance of consideration, by those qualified, not only of the evidence itself, but also of the methods and means by which a truly deplorable situation can be brought effectively under administrative control.[1]

---

[1] It has been pointed out in this connection that the "importance of dust of various kinds as a causative factor in respiratory diseases is being borne in upon us with greater weight. Heim and Agasse-Lafont (*Arch. gen. de med.*, 1914), after reviewing the various ill effects of industrial dusts, came to the conclusion that the classification should not rest upon the origin of the dust, but rather upon the nature of its harmful influence. They recognize dusts of an active and of a passive nature. The effects of the first are toxic, predisposing or infectious, while the dusts acting passively act by their mere presence as foreign bodies upon the surfaces of the respiratory system. These passively acting materials may be of soft or hard consistency. The latter are more effective in bringing about the common chronic pneumoconiosis. They point out that the active agents are by far the most important in bringing about the acute respiratory diseases of which pneumonia and acute bronchitis are the most frequent. They do not follow the chronic lesions resulting from passive agents to a conclusion to illustrate the increased predisposition of the damaged tissues to other secondary processes."

RELATION OF ATMOSPHERE TO LIFE AND HEALTH.

The relation of the atmosphere to human life and health has been made the subject of numerous scientific investigations. For a number of years prize essays have been published by the Hodgkins Fund of the Smithsonian Institution, established for the purpose of increasing human knowledge regarding a problem of great practical and every-day importance. In 1896, through the medium of the fund, there was published an essay by Francis Albert Rollo Russell on "The atmosphere in relation to human life and health,"[1] in which, among other basic facts, the following is laid down as a prerequisite for the rational understanding of the scientific questions involved in a consideration of the atmospheric influence on health and longevity:

The average volume of air breathed in at each breath is about 30 cubic inches, and the volume of air which may be breathed in by an effort, and by expanding the chest, is about 130 cubic inches, or about four times as much. After a very full inspiration about 230 cubic inches can be expired by a man of average height and in good health. The total capacity of the lungs, however, is much more than this—about 330 cubic inches. Thus in ordinary quiet breathing we only fill about one-tenth of the available air space of the lungs. After every outbreath, or expiration, a quantity of air is left in the lungs. This residual air amounts to about 100 cubic inches. An adult at rest breathes about 686,000 cubic inches in the course of 24 hours; a laborer at full work, about 1,586,900 cubic inches—more than double. The amount of air passing into the lungs per diem has been estimated at 400 cubic feet in a state of rest, 600 in exercise, 1,000 in severe exertion. The number of air cells in the lungs is estimated at 5,000,000 or 6,000,000 and their surface at about 20 square feet. The epithelium or membranous film between the blood and air is exceedingly thin, and in many parts the capillaries are exposed, in the dividing walls of cells, to air on both sides. The weight of air inhaled in the course of the day is seven or eight times that of the food eaten. The mechanical work of breathing represents energy expressed by the lifting of 21 tons 1 foot in 24 hours. From every volume of air inspired about 4½ per cent of oxygen is abstracted, and a somewhat smaller quantity of carbonic acid gas is at the same time added to the expired air.[2]

PRACTICAL IMPORTANCE OF ATMOSPHERIC PURITY.

The foregoing extract emphasizes the importance of atmospheric purity under working conditions, since, as said in the statement quoted, the amount of air passing into the lungs in 24 hours in a state of rest is about 400 cubic feet, in normal exercise 600, and in severe exertion 1,000. Considering this fact in connection with conditions of work in metal mining, for illustration, brings out in a startling way the strikingly injurious effect of the continuous inhalation of air grossly polluted by minute particles of mineral and metallic dust, aside from gaseous impurities which, under given conditions, may add materially to the health-injurious results of dust exposure. As observed in the same essay, "The deficiency of oxygen and excess of carbonic acid, which are common to nearly all living rooms, schools, churches, theaters, and workshops where many persons are gathered, are very favorable not only to the spread of various infectious diseases, but to the maintenance of a number of minor ailments; and where the exposure to foul air is prolonged, as in workshops, offices, and mills, to a continued depression of vitality." In the same connection it is pointed out that the normal requirement is the supply of about 3,000 cubic feet of fresh air per head per hour, which, it is safe to maintain, is rarely met with in any of the dusty trades in which the mortality from tuberculosis materially exceeds the average for out-of-door occupations.[1]

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[1] See also in this connection "The atmosphere in its relation to the human mechanism," by R. C. Holcomb, surgeon, U. S. Navy, in U. S. Naval Medical Bulletin, vol. 10, No. 3, Washington, 1916.

[2] See also an article in the Scientific American Supplement, July 1, 1916, on "Modern air," by Prof. John F. Norton, Ph. D.

AIR CONTAMINATION AND DISEASE RESISTANCE.

Aside from atmospheric impurities of an inorganic nature, of which dust in the more restricted sense of the term is chiefly constituted, the air is frequently contaminated by living germs, the microbes, bacteria, fungi, and molds, which may, or may not be, of a pathogenetic, or disease-producing, nature. Experiments have conclusively proved that microbes are much more abundant in the town than in the country, and, as a general rule, they are more frequently present in dwellings and workshops than immediately outside of the habitations or buildings concerned. Most of the germs and spores which are inhaled are not directly injurious, as far as known, but there are reasons for believing that the vitality is always reduced by a contaminated atmosphere, irrespective of the nature of the inorganic or organic impurities. Russell, in his discussion of "The atmosphere in relation to human life and health," concludes that—

> Many severe forms of disease, especially of the respiratory organs, are caused by the dust inhaled in various trades and occupations. These are generally proportionate to the sharpness and angularity of the dust and its quantity. Coal dust is among the least harmful. Among lead miners, bronchitis and lead poisoning; in copper mines, gastric disorders; in pottery works, in stonecutting, steel grinding, in flax and cotton factories, in shoddy works, and in metal polishing, lung diseases are common, and the death rate is high. Thus the

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[1] See a paper by Miller and Cocks on "Effects of changes in atmospheric conditions upon the upper respiratory tract," in Transactions of American Climatological and Clinical Association, 1915.

mortality of file makers was 300, compared with 108, that of gardeners; of earthenware makers 314, compared with 139, that of grocers; of cutlers and scissors makers 229, compared with 129, that of paper makers. The dust of soft woods and of flour seems to have little bad effect. As regards phthisis and lung diseases the figures of several trades are as follows, when compared with fishermen, 100: Carpenters, 170; bakers, 201; cotton workers, 274; file makers, 396; stone and slate quarrymen, 294; pottery makers, 565; northern coal miners, 166. The injuriousness of the dust in cotton mills is increased by the use of mineral substances for sizing. The mortality of cutlers, etc., from these diseases is almost as great as that of fishermen from all causes put together, including accidents. The comparative exemption of colliers in well-ventilated coal mines deserves investigation, for there would appear to be some ground for the supposition that it may be owing to the inhibitive action of this particular dust upon the development of tuberculosis; on the other hand, it may be simply through living in fairly good air of an even temperature, where the specific germs of phthisis are few or absent. The homes of the men are generally comfortable, and much larger fires are kept up than in the South, so that their rooms are dry and well ventilated.

CHEMICAL ASPECTS OF ATMOSPHERIC POLLUTION.

Within recent years there has been an important change of qualified opinion regarding the health-injurious consequences of atmospheric pollution due to chemical causes. In a publication of the Hodgkins Fund, issued by the Smithsonian Institution in 1913, on "The influence of the atmosphere on our health and comfort in confined and crowded places," by Leonard Hill, Martin Flack, James McIntosh, R. A. Rowlands, and H. B. Walker, an effort is made "to demonstrate that no evidence has yet been brought forward which shows that the chemical quality of the air has anything to do with these ill effects, and that, apart from the influence of infecting bacteria, the ventilation problem is essentially one of temperature, relative humidity, and movement of the air." This important conclusion is diametrically opposed to the principles generally laid down in elementary textbooks on hygiene that the chemical aspect of atmospheric pollution is of fundamental importance, and that the effects of life and work in ill-ventilated rooms or workshops are attributable to changes in the chemical quality of the air, whether it be want of oxygen, or excess of carbon dioxide, or the addition of some exhaled organic poison, etc. The authors maintain that the terms "devitalized" or "dead" air are misleading, and, differing from the prevailing opinions, that the health-giving properties of a pure atmosphere are "primarily those of temperature, light, movement, and relative moisture." None of these observations or conclusions, however, bears upon the broader problem of atmospheric pollution by dust in any of its many varieties, which to a measurable degree reduces vitality and predisposes to respiratory and tuberculous diseases, but chiefly tuberculosis of the lungs.[1]

THE INFECTIOUSNESS OF TUBERCULOSIS.

As early as 1881–82, when the infectiousness of tuberculosis had just been determined by the discovery of the bacillus of the disease by Koch, Dr. Arthur Ransome, in an address before the Manchester and Salford Sanitary Association pointed out that—

> Wherever people are collected together, the death rate from consumption is in direct proportion to the degree of crowding together, and to the deficiency of ventilation. I will give only one instance of this, that was first remarked by Dr. Guy, with reference to letter-press printers. He found that of 104 compositors who worked in rooms of less than 500 cubic feet for each person 12.5 per cent had had spitting of blood; of 115 in rooms of from 500 to 600 cubic feet, 4.35 per cent showed this sign of consumption; and in 100 who worked in rooms of more than 600 feet in capacity, less than 2 per cent had spat blood.[2]

LUNG INJURY FROM IRRITATING DUSTS.

The same author, in an address on the "Prevention of consumption," delivered on September 22, 1887, before the Sanitary Congress at Bolton, directed attention to the relation of the inhalation of irritating substances, or dusts, arising from various kinds of industrial activities, such as steel grinding, glass cutting, brush making, etc., to the relative frequency of the disease, and he amplified his observations by quotations from the medical reports made by Dr. Headlam Greenhow to the Privy Council in 1860 and 1861, in which attention was called to the large mortality from tuberculous complaints among "those who worked in an atmosphere impregnated with dust consisting of fine particles of metal or of sandstone, etc." Granting that no statistical evidence can materially aid in disclosing the immediate causative factors of the disease, Ransome observes that—

> No one, indeed, who has studied the vital statistics of these occupations, or who has medically attended the workpeople, can doubt

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[1] Bandelier and Roepke, in their treatise on A Clinical System of Tuberculosis (London, 1913, pp. 14, 15), mention among the acquired predisposing influences favorable to the disease "slight injuries to the smallest bronchial tubes from the inhalation of particles of mineral, metallic, vegetable, or animal dust." They add thereto that "the harder, sharper, more pointed the dust particles, the more likely are they to injure the lung tissue, to open the way to tubercle bacilli, and to favor their development by setting up chronic inflammation. Likewise some substances, as corrosive vapors and gases, cause chemical injuries." They conclude that:

"As anatomical lesions may be caused by various fine mechanical irritants, so gross traumatic injuries from direct or indirect violence (punctures, shots, blows, falls, and crushing) produce injury to the lung tissue and favor possible infections. But much more frequently it will happen that a latent inactive focus, usually in the bronchial glands, is brought into activity by an injury, or a latent but active tuberculosis made evident, which, however, is the same thing from the legal point of view."

[2] A Campaign Against Consumption, by Arthur Ransome, M. D., London, 1915, p. 9.

the power of irritating dusts in inducing a state of the lungs that is favorable to the reception of the specific organism.

He, therefore, concludes that—

> Just as in the case of lungs otherwise injured tubercle may readily be ingrafted upon a miner's or a needlemaker's lung; but the disease that is first caused by the particles these men inhale is not tuberculous at all. It is simply a chronic inflammation, affecting chiefly the connective tissue and causing the formation of a fibroid tissue in the alveolar walls. It leads ultimately to a contraction, and, so to speak, a strangling of certain portions of the lung tissue. But no bacilli are found either in the tissues or in the expectoration of such patients, as I can testify from frequent stainings.[1]

This conclusion, which is of great practical importance, is frequently ignored in superficial discussions, particularly of miners' lung diseases, which in their origin are not tuberculous, but rather a fibrosis ultimately terminating in a true tuberculosis in consequence of a subsequent infection. Ransome is, therefore, apparently quite justified in his statement that "Dusts, although they are a serious danger, and though they ought on this account to be kept away from workpeople as a preventive measure against consumption, are yet only remotely a cause of the disease." It, however, has probably never been seriously maintained by anyone familiar with the subject that the inhalation of health-injurious dust is to be considered a primary cause of tuberculosis, but it is rather to be looked upon as a more or less injurious contributory causative factor, largely amenable, within reasonable limits, to effective methods of administrative sanitary control.

VARIED FORMS OF PULMONARY TUBERCULOSIS.

Pulmonary tuberculosis exists in many and varied forms. As said in a treatise on The Expectation of Life of the Consumptive after Sanatorium Treatment, by Noel D. Bardswell—

> The disease, for instance, may be very acute and prove fatal in a few weeks (miliary tuberculosis), it may commence very acutely and gradually develop into a more chronic process; or, again, it may from its commencement run a slowly progressive course, extending in all over a great many years. This last form, by far the commonest type of the disease, is generally spoken of as "chronic" pulmonary tuberculosis. It has for long been recognized that the prognosis, or expectation of life, in these various types of pulmonary tuberculosis is widely different; hence the necessity for considering them separately when dealing with statistics as to the curability of the disease as a whole.

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[1] A Campaign Against Consumption, by Arthur Ransome, M. D., London, 1915, p. 26.

Unfortunately, the mortality statistics, as a general rule, do not permit of such a precise differentiation, and least of all in their practical application to tuberculosis as an occupational disease. The five forms of tuberculosis generally distinguished are tuberculosis of the lungs, acute miliary tuberculosis, tuberculous meningitis, tuberculosis of other organs, and disseminated tuberculosis. In the United States registration area, during the period 1911 to 1915, the mortality per 100,000 of population, from these five groups was as follows: Tuberculosis of the lungs, males, 139.8, females, 109.5; tuberculous meningitis, males, 8.8, females, 8.1; tuberculosis of other organs, males, 9.9, females, 9.7; and disseminated tuberculosis, males, 1.3, females, 1.2. It is therefore shown that tuberculosis of the lungs is of primary importance; but the different forms of pulmonary tuberculosis are not disclosed by the general mortality returns.

COMPARATIVE MORTALITY STATISTICS.

The term "phthisis" is generally used as a convenient expression for the term "tuberculosis of the lungs."[1] Extreme caution is necessary in the use of international tuberculosis statistics, since there are reasons for believing that the same terms have not an identical meaning in foreign usage. The mortality from phthisis in England and Wales, for illustration, is invariably lower than in this country; in contrast, the mortality from bronchitis, both acute and chronic, is decidedly higher. In England and Wales the mortality from tuberculosis during the period 1911 to 1915, per 100,000 population, was as follows: (1) Tuberculosis of the lungs, males, 115.8, females, 80.0; (2) acute miliary tuberculosis, males, 11.2, females, 9.3; (3) tuberculous meningitis, males, 15.3, females, 12.7; (4) tuberculosis of other organs, males, 16, females, 13.1; (5) disseminated tuberculosis, males, 6.9, females, 5.3. In other words, all the nonpulmonary forms of tuberculosis are more common in England and Wales than in the United States registration area. In the latter the mortality from bronchitis was 17.1 for males and 19.5 for females; but in contrast, the corresponding mortality for England and Wales was 114.7 for males and 109.4 for females. These and many other statistical facts should be kept in mind in an effort to interpret with at least approximate accuracy the comparative international statistics of tuberculosis with special reference to occupation and the incidence of tuberculosis in the dusty trades.

The table following shows the comparative international death rates for tuberculosis for the years 1911 to 1915, inclusive.

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[1] The strictly technical medical aspects of the questions involved in the precise definition of tuberculosis versus phthisis are summed up by Maurice Fishberg, M. D., in his treatise on Pulmonary Tuberculosis, Philadelphia and New York, 1916, p. 103.

TABLE 2.—DEATH RATE PER 100,000 OF POPULATION FROM PULMONARY AND ACUTE MILIARY TUBERCULOSIS, 1911 TO 1915.

Year.	United States registration area.		England and Wales.		Scotland.		Ireland.		Australia.[1]	Holland.[1]	Norway.[1]	Switzerland.[1]
	Pulmonary.	Acute miliary.	Pulmonary.	Acute miliary.	Pulmonary.	Acute miliary.	Pulmonary.	Acute miliary.				
1911	132.5	5.5	99.1	9.3	110.1	6.9	169.4	3.6	70.5	118.8	176.0	161.5
1912	124.8	5.0	94.3	10.3	108.1	5.8	164.1	5.9	67.7	110.7	176.0	150.3
1913	122.8	4.9	91.3	9.9	104.3	5.4	163.4	4.8	67.7	106.4	173.7	147.2
1914	123.1	4.7	94.5	10.0	100.6	4.4	160.5	3.0	63.2	107.3	175.9	143.6
1915	123.0	4.7	106.6	11.3	107.9	4.0	172.2	1.8	62.1	110.1	175.5	141.1

[1] Includes both forms.

INDUSTRIAL LUNG DISEASES.

In this connection it has been appropriately said by J. M. Beattie, M. D., in an address on the "Hygiene of the steel trade," contributed to the Transactions of the Royal Sanitary Institute of Great Britain (Vol. XXXIII, 1912, p. 501), that—

> A great deal of attention has been centered on the dust problem, and much of the legislation relating to the industries with which we are dealing is concerned with the protection of the workers from dust inhalation. A much more serious problem, however, is the prevention of infection with *B. tuberculosis*, which has not received justice at the hands of factory inspectors and factory legislators. During a five years' experience in Sheffield it has been abundantly demonstrated that cutlers and grinders die from tuberculosis and not from nontuberculous fibrosis of the lungs.

Dr. Beattie therefore strongly protests against the loose use of the word "phthisis" and remarks—

> Rightly or wrongly, phthisis is now understood by medical men to mean tuberculosis of the lungs, with cavity formation; and the term "grinders' phthisis" should be confined to that condition of the lung in which tuberculosis is added to the interstitial fibrosis. For the condition which is produced by the inhalation of dust, the term "fibrosis" is perhaps the most suitable; I shall therefore describe the condition resulting from the inhalation of dust as fibrosis. The misuse of the term "phthisis" makes it difficult to obtain entirely satisfactory statistics, and we can only, therefore, regard the usual data as an approximation to the truth.

LIMITED VALUE OF OCCUPATIONAL MORTALITY STATISTICS.

Dr. Jacques Bertillon, in a paper on "Mortality and the causes of death according to occupations," contributed to the Transactions of the Fifteenth International Congress on Hygiene and Demography (Vol. I, 1912, p. 339), points out that—

> The frequency of phthisis varies much with the occupation. If a man is poisoned either by alcohol or by lead, phthisis is very common.

It is common, also, in most occupations in which the man is exposed to dust, especially mineral dust. It has an average frequency in occupations pursued in confined quarters. It is infrequent with shopkeepers, in the liberal professions, and especially among farmers, as well as in most occupations carried on in the open air and involving muscular exercise. It is very uncommon among iron and coal miners. These are the general conclusions indicated by my figures and the diagram. They are subject to many exceptions which should be examined more closely.

These cautious observations regarding the general use of occupational mortality statistics apply to English and American as well as to French, German, and other continental data. The same qualification applies to the terminology of the disease and the contributory atmospheric conditions such as dust and gaseous impurities. Simeon Snell, M. D., in an address on "Coal mining and the health of colliers," contributed to the Transactions of the Sanitary Institute of Great Britain (Vol. XVI, 1895, p. 110), directed attention to the fact that—

The influence of dust, whether metallic or nonmetallic, in the production of phthisis is now well known, and the subject received attention in these lectures last year. A collier passes a third of his day in an atmosphere which is laden with fine particles of coal dust. Mines differ very much in the prevalence of this dust. Thus men speak of the mines in which they work as being dusty or not. A dry mine will be dusty, and a wet one not so much so. That colliers will be constantly breathing these fine particles can not be questioned, and yet Dr. Ogle says that "Be the explanation what it may, there can be no possibility of doubt that the mortality of coal miners from phthisis is remarkably low."

DUSTS AND FUMES, FOES TO INDUSTRIAL LIFE.

The relative immunity to pulmonary tuberculosis of coal miners seems to be conclusively established; but in contrast to a low death rate from tuberculous disease, coal miners almost invariably experience a high death rate from nontuberculous lung diseases. Among the important contributions to the subject are the results of the investigations of Sir Thomas Oliver, M. D., included in an address on "Dust and fumes, foes to industrial life," published in the Transactions of the Fifteenth International Congress on Hygiene and Demography (Vol. I, pp. 309, 322, 327, 332), restated, in an abbreviated form, as follows:

Dust, smoke, and fume are the products of industrial activity to be feared. In what relation do these stand to each other? Dust is usually regarded as matter in a state of fine division, but modern research shows that dust, from a medical point of view, is something more than this. Smoke and fume differ from dust in being the products of heat, and these two again differ from each other in this respect, that smoke is the outcome of incomplete combustion of hydrocarbons, such as coal, wood, and oil, while fume is, firstly, the gaseous form of metals, nonmetals, and their compounds, and, secondly, the return of these from the gaseous to the solid state, as seen in the flue deposit of a lead smelting factory. Soot, on the other hand, is a hydrocarbon, which has not completely combined with oxygen to form gases.

Although we are more immediately concerned with the effects of dust upon the lungs, yet the whole body, including the skin, mucous membranes, and the internal organs, suffers in due course by exposure to dust. We seldom think of the part which dust and smoke have played indirectly in shaping the social habits of a people. How to get rid of dust and fume in the factory, of smoke in the atmosphere, and of the incidence of all these upon the skin and the respiratory organs of man has formed not only the subject of many a scientific discussion, but has stimulated enterprise and encouraged manufacture. In trying to combat their begriming effects we have become a well-washed people. The dispersion of these waste products has led to the manufacture and use of soap in proportions hitherto unparalleled in the history of man, while these again have indirectly added to employment, wealth, and health. Frequent ablution has become the rule, so that baths, a luxury to the Romans in the palmy days of empire, and unknown in even large houses in my own country four or five decades ago, are now a necessity, for they find a place in many of the modern houses of the working classes. Dust and fume, begriming agents as they are, have therefore done something to socialize mankind, to promote health, and to advance civilization, for those nations are leading in the path of progress to-day whose workers not only require soap and water for themselves, but who, by the factory dust and smoke they create, oblige all of us to resort to similar usages.

What are the possible remote effects of carbon monoxide? Pneumonia sufficiently frequently develops in miners who have been exposed to the firing of explosives as to suggest a causal relationship between the two. Dr. Hotchkiss, of the United States Public Health Service, states that in the Cripple Creek district one man died of edema of the lungs, probably the result of exposure to powder smoke, and that in the same district 20 similar cases had been reported within 10 years, of which 18 proved fatal. Dr. Dale Logan tells me of two men who returned to a particular working in a coal mine three and one-half minutes after having exploded 1 pound of gunpowder. Shortly afterwards both complained of the foulness of the air and of their work becoming more difficult; they also had headache, giddiness, and vomiting. They made their way home, staggering all the way. In the case of one of the men speech was so thick that his wife could not understand what he said. Both men seemed to be intoxicated. During the night one of the men vomited frequently. Next day, although giddy and suffering from headache, he returned to work, but on the second day he developed pneumonia and died from it on the fourth day. The pneumonia was regarded as the sequel of carbon monoxide poisoning, and compensation was awarded. Among South African miners pneumonia is extremely common. It is very fatal both to white men and to black, owing largely to the diminished vital resistance, caused by breathing mine air charged with the products of explosives. Sudden exposure to air containing a large percentage of carbon monoxide gives rise to serious symptoms which immediately attract attention, but the effects produced upon men by the combined influence of fatigue and of breathing for several hours daily small percentages of carbon monoxide in the high temperature of the mine are not so well known. Although the symptoms observed in miners after the use of explosives are for the most part due to CO, it is not maintained that nitrous fumes can be inhaled with impunity. On the contrary, owing to their irritating properties, they set up congestion of the lungs with edema. In an ordinary way the symptoms appear much earlier than those caused by carbon monoxide. Shortly after exposure to nitrous fumes, a burning sensation in the nostrils and throat is complained of, followed by a dry, hacking cough, and by expectoration frequently tinged with blood. Should the miner die, the mucous membrane of the trachea and bronchi is found to be acutely congested, and there are signs of acute bronchopneumonia and hemorrhagic edema of the lungs.

What becomes of the dust when it is inhaled? It is a natural supposition that, while some of it reaches the lungs, the major part of it is retained in the nares. Saito, working in Prof. K. B. Lehmann's laboratory in the Institute of Hygiene in Wurzburg, has tried to determine experimentally the fate of dust breathed by workmen in factories. In his preliminary experiments dogs and rabbits inhaled air charged with white-lead dust from 1 to 33 hours. He found that the greater part of the dust was subsequently recovered not from the lungs, as might have been expected, but from the alimentary canal. In five out of six experiments 4 to 24 per cent of the total amount of lead dust breathed in was located in the respiratory organs and the remainder in the digestive. In an ordinary way the dust caught in the nasal mucous membranes mixes with the mucus which is secreted and is unknowingly swallowed. Experiments were also carried out on man with white-lead dust, the mouth and nares being previously carefully washed. The experiments were conducted from 10 to 15 minutes on 20 occasions, care being taken by the men not to swallow the saliva. Inspiration and expiration took place through the mouth and nose, singly and combined, with the result that, provided sneezing did not take place, 95 per cent of the dust inhaled remained behind in the body, 50 per cent of which was primarily retained in the nares. By processes of exclusion 12 per cent probably finally found its way into the lungs, for the bulk of the lead dust, 60 to 80 per cent, was recovered from the alimentary canal. Saito's experiments demonstrate that the principal portal of entrance of soluble dust into the body when inhaled is the alimentary canal and not the lungs. Where two such channels of entrance as the respiratory and alimentary are so close to each other, it is not always easy to say upon which the dust has exerted its baneful influence. In Laborde's experiments with guinea pigs exposed to air laden with fine white-lead dust, the animals died within two hours. In the lungs were found intense congestion and ecchymoses. When the exposure was less intense and the animals lived longer, similar but equally profound vascular changes were found in the lungs, pointing, therefore, to direct irritation by dust.

In my early cases of gold miners' phthisis the physical signs showed that the disease was located for the most part toward the base of one or other of the lungs. The men, although bronzed and healthy looking, were yet the subjects of a difficulty of breathing on the slightest exertion, a difficulty of breathing far in excess of what the physical signs on examination of the chest suggested. In its inception pneumoconiosis is a nontuberculous disease; it is the direct result of dust irritation. The course of the malady is hastened by the recurrence of bronchial and pulmonary catarrh. The changes set up in the lungs by previous catarrh prepare the soil for infection by tubercle; but in some of my patients the disease ran its course from commencement to finish without becoming tuberculous. Within recent years a change has apparently been taking place in the mines on the Rand. Ten years ago, when I first drew attention to gold miners' phthisis, there was a much smaller percentage of tuberculous disease amongst the men than in recent years. In making this statement I am supported by the medical experts of the recent commission, who report that it was the opinion of the medical men on the Rand who examined patients in 1902–1904, that at that period miners' phthisis terminated fatally without any clinical or bacteriological evidence of tubercle and that men continued at work until a week or two of their death, which often came by heart failure, with cyanosis and urgent dyspnea. Death, indeed, sometimes came to men quite suddenly from heart failure when they were working in the mine. As it is not always easy to find the bacilli of Koch in the sputum even of ordinary cases of pulmonary tuberculosis, so their absence for months from the expectoration of a gold miner is no proof that the disease in him is not tuberculous. When, however, tubercle bacilli are absent all through the illness and the lungs after death do not give evidence either macroscopically or microscopically of tubercle, then gold miners' phthisis in its typical form is nontuberculous. Sooner or later, as the malady progresses, tubercle becomes grafted upon the pulmonary lesions, and with the invasion of the microorganisms the character of the illness becomes almost immediately changed. While the hard and fibrotic portion of the lung of a gold miner is not a suitable soil for microorganisms the concurrent catarrhal conditions in other parts of the lungs offer little resistance both to the bacillus of Koch and the pneumococcus of Friedländer, and yet I have seen a Rand miner with silicosis in the early stage develop an acute inflammatory affection of the lungs, with high temperature and with physical signs indicating extensive consolidation, make an excellent recovery. In the case I refer to the microorganism found in the expectoration was the bacillus catarrhalis. In the Transvaal the high mortality rate of miners from pneumonia led the mining authorities of South Africa a few months ago, with the view of treating the disease by a vaccine, to call to their assistance the service of Sir Almroth Wright. The high death rate from pneumonia and the increasing number of cases of gold miners' phthisis, which in later years have been assuming a tuberculous type, raises the question as to whether the mines themselves or the lodgings of the men may not be partly responsible for this fact.

Since dust is the foe of workmen means ought to be employed for its removal from factory and workshop. General ventilation is all very good, so long as the question is simply one of a vitiated atmosphere due to the air having been rendered impure by the respiratory products of the workpeople, and by artificial heating and lighting, but where the dust is generated by machinery or is evolved during the ordinary course of production general ventilation only disseminates the dust, so that recourse must be had to local ventilation such as is afforded by an exhaust apparatus. Exhausts are superior to water spraying. The wearing of respirators is no doubt in many instances a necessity, but the men complain of the heat engendered by them and of the restraint imposed upon their breathing. Still it remains a fact that men working in color grinding, when they have taken to wearing respirators, have recovered the weight they had lost and regained their health.

OBSERVATIONS ON THE AIR IN MINES.

In this connection the further observations by Sir Thomas Oliver on fumes more or less contaminated by dust are also of exceptional practical importance. The extract is from an address on "The metallic poisons, lead and arsenic, as met with in our industries," contributed to the Transactions of the Sanitary Institute of Great Britain (Vol. XIV, 1893, pp. 157–161):

Carbonic acid is one of the great dangers to the men, and there is a tendency for it always to be present in excess, as it is given off from the lungs of the miners in respiration, and the combustion of the candles, as well as from the strata in which the men are working. Add to these facts the deterioration of the air of the mine by the use of dynamite and from the explosions of gunpowder, and you have an atmospheric condition in the mine which frequently obliges the men to retire to the mouth of the pit in order that the needs of respiration may be satisfied. What with the impure air and the inhalation of the dust and grit from the limestone rock, the lead miner is exposed to risks that are in constant operation during the whole period he is at work. When to these are added the fact that the mines are warm and the men on leaving are overheated, owing to the exertion required in scaling the ladders, and are obliged to trudge home 2 or 3 miles across a bleak moor exposed to biting winds and in all kinds of weather, we can readily understand how it is that many of them succumb to such acute illnesses as pneumonia, or how the neglected cold or pleurisy, acting in conjunction with a family predisposition, too frequently throws the miner into consumption.

When we come to consider the manufacture of white lead, we observe that at certain stages of the process a good deal of dust is evolved. It is the inhalation of this fine penetrable dust, and the fact that women are largely employed in the trade, that have gained for this industry a bad name. We believe that women are much more susceptible to the influence of lead than men. This statement, for which I am largely responsible, has been disputed, but an increasing acquaintance with the subject, an extensive hospital experience of plumbism, and renewed experimental investigation upon animals, lend weight to the opinion that women are not only more susceptible than men but they are so at an earlier age. In addition, there is a greater tendency for lead poisoning to assume its most serious form, in which headache followed by convulsions and coma are the most prominent symptoms.

PRINCIPLES OF TUBERCULOSIS PREVENTION.

The conveyance of tuberculosis infection through the medium of industrial dust has been referred to with brevity in an address of exceptional importance on "The prevention of tubercular disease," by Sir James Crichton-Browne, contributed to the Transactions of the Sanitary Institute of Great Britain (Vol. XV, 1894, pp. 445, 446, 448), as follows:

> The presence of tubercle bacilli and their spores in the air breathed by consumptive patients, floating independently or buoyed up by particles of dust, is now indisputable. Dr. Williams hung up glass slides smeared with glycerin in the ventilating shafts of the Brompton Hospital and shortly found tubercle bacilli adhering to the glycerin; and Dr. Cornet, by elaborate experiments, conducted in the rooms of private consumptive patients and in hospitals, has shown that tubercle bacilli are expired by consumptive patients in small numbers, and that they and their spores, which, remember, are very indestructible and will retain their vitality even when dried, are given off in clouds from the handkerchiefs and bed linen of consumptive patients and from the floors or walls of the rooms they inhabit, if they are not scrupulously cleanly in their ways—from any place or thing, in short, with which their expectoration has come in contact. Cornet has further shown that tubercle bacilli may be caught in open spaces and in the air of streets and squares where tubercular persons are present, and in all these cases he has shown that the dust collected when inoculated into animals sets up tubercular disease. Klein has shown that guinea pigs become tubercular when finely divided tubercular matter is diffused by a spray producer in the air of their hutches, and he has succeeded in communicating tubercle to those animals by keeping them for a time in cages in the ventilation-extraction shaft at the Brompton Hospital, through which the foul air from the wards passes. And quite recently M. Straus has communicated to the Académie de Médecine in Paris a very instructive observation. By means of little plugs of cotton wool the dust and mucus from the nasal orifices of 29 healthy nurses and medical students serving in the wards of hospitals containing consumptive patients were collected, and solutions prepared from these were injected into 29 guinea pigs, of which 9 manifested tubercular disease within a month. There can no longer be any doubt that the air of apartments occupied by consumptive patients is loaded with virulent dust; that the germs of tubercle exist in the atmosphere of all populous districts; and that the inhalation of the dried virus floating in the air is one of the commonest ways of the propagation of the disease.
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> Then ventilation is not less necessary for the prevention of tubercular diseases in mines, factories, and workshops than it is in public institutions. The loading of their atmosphere with particular kinds of dust appertaining to the trades carried on in them is a prolific cause of tubercle in the lungs, and we have come to speak of miners' and knife-grinders' and potters' consumption. The dust in such cases penetrates the lungs and by its hardness and angularity wounds the mucous membrane, setting up irritation and catarrh and

creating that raw surface on which the tubercle bacillus loves to fasten and batten.

VENTILATION AND DUST REMOVAL.

Dr. D. D. Kimball, in a paper on "Ventilation and public health," contributed to the Annals of the American Academy of Political and Social Science (Vol. XXXVII, No. 2, March, 1911, p. 212), directs attention to the fact that "Many ventilating systems are worse than useless because the air is taken in at or below the street level or from other dust-contaminated sources, and is passed into the building without filtration, the result being that the last state of the building is worse than the first." The problem of effective ventilation and dust control[1] does not, however, fall within the scope of the present discussion, but it is necessarily of the first importance in any and all efforts to mitigate the lamentable consequences which arise out of a needlessly dust-contaminated atmosphere, under which so large a number of industrial processes are carried on at the present time.

DUST IN RELATION TO OCCUPATIONAL DISEASES.

The importance of dust as a factor in occupational mortality has attracted the attention of every authority on occupational diseases from Ramazzini to Sir Thomas Oliver. It requires no extended consideration to prove that human health is much influenced by the character of the air breathed and that its purity is a matter of very considerable sanitary and economic importance. Aside from the risk of exposure to so-called air-borne diseases, the pollution of the atmosphere by organic and inorganic dusts is unquestionably the cause of a vast amount of ill-health and premature mortality, chiefly among men and women engaged in the many indispensable trades and occupations that minister to human needs. The sanitary dangers of air contaminated by disease-breeding germs are possibly not so menacing as generally assumed, while the destructive effects of the dust-laden atmosphere of factories and workshops are a decidedly serious menace to health and life. While the investigations of Dr. McFadden and Mr. Lunt seem to prove the paucity of bacteria in very dusty air, the evidence otherwise available is entirely conclusive that the risk to disease infection is much greater indoors than out in the open, where sunlight, rain, and wind in combination go far to purify the atmosphere by destroying the bacterial life contained in minute particles of suspended matter. Apart, however, from the transmission of disease through a dust-contaminated atmosphere, dust in any form, when inhaled continuously and in considerable quantities, is prejudicial to health because of its inherent mechanical properties, which are destructive to the delicate membrane of the respiratory passages and the lungs. It has long been known that those who live most of their time out of doors have a decided advantage over those who, because of their employment, are compelled to spend their working hours inside the home, the office, the factory, or the workshop, and it is an accepted axiom of modern sanitary science that measures and methods for the prevention of dust are an essential preliminary consideration in rational methods of sanitary reform. All that sanitary science can suggest or that sanitary legislation can regulate and change should be done for humane reasons and as a matter of governmental concern, to mitigate the needless hardships of those who suffer in health and life as the result of conditions over which they themselves have but a very limited control.

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[1] In a more recent address by Sir J. Crichton-Browne before the Sanitary Inspectors' Association of London (Modern Hospital, November, 1913), he observes that "town dust is most to be feared as a carrier of pathogenic germs and microbes of many kinds which can resist drying and may be wafted about with the particles. So catarrh, influenza, hay fever, etc., may be disseminated. Tuberculosis, too, is similarly spread in the dust of the dried sputum. In all dust the danger of implantation of germs, fresh or dried, is enhanced if associated with corrosive, chemical, or mechanically wounding elements. Sharp particles of mineral matter may plow a way in the tissues through which pathogenic germs may enter. Even tetanus might be caused by road dust carrying it to some superficial wound, for the organism lives in the alimentary canal of the horse, and so is found in the manure of street refuse as well as in the soil of gardens and other places. The tetanus antitoxin is efficacious if used immediately, and in these days of dust-scattering motors the president suggested that a tube of antitoxin might well form a part of the furniture of a car, so that in case of accident it might instantly be administered if any wound comes in contact with the dust."

The importance of dust as a factor in occupational diseases has been emphasized by all who have written on the subject, but by no one more precisely and clearly than by Sir James Crichton-Browne, in his address on "The dust problem," read at the Sanitary Congress held at Manchester, England, in 1902, from which the following profoundly suggestive extract is taken:

> The mortality of the principal dust-producing occupations, compared with that of agriculturists, who live and work in what is practically dustless atmosphere, *is excessive to a startling degree.* It is not suggested that this excess is to be ascribed to dust alone, no doubt various factors contribute to it, but the facts that it is due mainly to respiratory diseases, that it is distributed amongst the several occupations pretty much in proportion to their dustiness, and that it has diminished in some instances where dust has been effectually dealt with, justify the conclusion that it is largely dust begotten.

THE DUST PROBLEM IN INDUSTRY.

Sir Crichton-Browne in continuation of his remarks pointed out that a detailed examination of the conditions of work in each of the 22 principal dusty trades brought out clearly the fact that the unhealthiness was born of or was primarily due to the dust inhaled by the workmen, and that there was always a well-defined relation between the death rate and the quantity and quality of dust present in the atmosphere. There is apparently no very material difference in the manner in which the different varieties of dust act upon the human organism, except where, in addition to mechanically-injurious properties, the dust is of a poisonous character, which leads to diseases such as lead poisoning, phosphorus poisoning, anthrax poisoning, etc. Industrial mineral dust apparently acts with greater rapidity upon the lungs than organic dust, which is slower and more insidious in its operations, but in a general way follows similar lines. All varieties of dust that are the immediate result of occupation are therefore comprehended under the term of "industrial dust," which is specifically limited by Sir Crichton-Browne as follows:

> I select this dust for my further remarks, because it is readily recognized and defined, because its pernicious effects are well marked and indisputable, because it is to a large extent, if not entirely, preventable or removable, and because the efforts already made to prevent or remove it have been rewarded with conspicuous benefit. And I still further simplify and abbreviate what I have to say by restricting my observations to those varieties of it which are dust and nothing more, which are injurious by their physical properties and mechanical operations, and not as poisons to the systems, chemical destructives of the tissues, or bearers of bacterial invaders.

A similar but even more restricted limitation has been adopted for the present purpose, and only such occupations will be considered in detail in the following discussion as expose to the continuous and considerable inhalation of metallic and mineral, or other inorganic fiber dust, and in which the evidence is at least fairly conclusive that the resulting disease liability and mortality from tuberculosis and other respiratory diseases is above the average for occupied males generally.

SCIENTIFIC TERMINOLOGY OF INDUSTRIAL DUSTS.

Preliminary to a discussion in detail of the mortality from tuberculosis in dusty trades it may prove of some advantage to those who do not have access to the original sources of information to present a brief summary of qualified medical opinion regarding dust as a factor in occupation diseases and mortality. In a course of lectures on "Unhealthy trades," delivered before the Society of Arts, London, in 1876, Dr. B. W. Richardson[1] placed injuries from the inhalation into the lungs of fine particles of solid matter, usually defined as dust, at the head of the causes responsible for industrial diseases, and from his discussion the following is quoted:

> The term "dusts," as I would here apply it, includes all those fine, solid particles which are thrown off from various substances in the processes of manufacture or treatment of articles in common use in

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[1] Scientific American Supplements, Nos. 9, 10, 18, 19, and 22, dated, respectively, Feb. 26, Mar. 4, Apr. 29, May 6, and May 27, 1876.

daily life, such as earthenware utensils, knives, needles, or mechanical instruments, like files or saws; or ornamental things, such as ornaments of pearl, ivory, and turned wood; or articles that are worn, of silk, cotton, hemp, fur; or things that are used for food, such as flour; or for creating warmth, such as coal; or for using as a supposed luxury, such as tobacco and snuff. These are only a few illustrations; many others will naturally occur to those who think on the subject.

The dusts which inflict injury are of varied quality, as will be seen from the brief sketch just given. They are also of varied effect in regard to the specific injuries which they produce. We may profitably study them divided into different groups, according to their physical characters, as follows:

(*a*) Cutting dusts, formed of minute hard, crystallized particles which have sharp, cutting, and pointed edges. These dusts are composed of iron or steel, of stone, of sand or glass, of dried silicates in earthenware, of lime, of pearl.

(*b*) Irritant dusts, derived from woods, from ivory, from textile fabrics, fluffs of wool, of silk, of cotton, of flax, and of hemp, from hair, from clay.

(*c*) Inorganic poisonous dusts, derived from some poisonous chemical compounds used for coloring artistic products, or for preserving organic substances, such as furs. These dusts are charged with arsenical salts.

(*d*) Soluble saline dusts, derived from soluble crystalline substances used for dyeing purposes. The sulphate of iron, copperas, yields a dust of this class.

(*e*) Organic poisonous dusts, which are thrown off during the making up of tobacco into cigars and snuff. These dusts carry with them particles of the dried tobacco plant.

(*f*) Obstructive and irritating dusts composed of carbon, of fine particles of coal dust, of scrapings of carbon or of soot, of dust of rouge, and of flour.

Whatever may be the kind of dust to which the workman is subjected, to whichever of the above named he may be exposed, the primary cause of danger lies in the circumstance that the fine particles are borne by the air into the lungs. They pass, wafted by the air, through the mouth and nostrils into the windpipe; they pass along the bronchial tubes; in some instances they reach and traverse the bronchial passages which lie between the larger bronchial tubes and the minute air vesicles, or they even reach the air vesicles themselves.[1]

DISEASES RESULTING FROM DUST INHALATION.

An American authority on occupational diseases has referred to the subject at some length in an article contributed to Buck's Hygiene and Public Health, printed in 1879. This writer, Dr. Roger S. Tracy, for many years registrar of vital statistics of New York City and sanitary inspector of the board of health, makes the following statement, with particular reference to the special form or type of disease resulting from the inhalation of metallic and mineral dusts:

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[1] One of the most important contributions to the scientific study of industrial dusts is the second and enlarged edition of a treatise issued by the Museum of Industrial Hygiene of Vienna in 1895. The title of the publication is "In den gewerblichen Betrieben vorkommende Staubarten in Wort und Bild." The publication includes 14 pages of 56 micro-photographic illustrations of typical industrial dusts and an extended explanatory text by Dr. F. Migerka, with the divisions of: (1) metallic dust, (2) mineral dust, (3) dust in polishing and turning, (4) wood dust, (5) textile dust, (6) miscellaneous dust. It is regrettable that this valuable treatise should not have been translated into the English language.

> The disease comes on very gradually, like the more slowly developed forms of phthisis pulmonalis, and its duration may be extended over four or five years. It begins with the cough of irritation, dry and hacking at first, with very scanty expectoration, whitish and stringy in character; there is no hæmoptysis, but sometimes nausea and vomiting in the morning. Auscultation at this time reveals puerile respiration, with occasional slight râles. The expectoration gradually increases in amount and becomes reddish, and soon after this tinge appears there may be hæmoptysis. There is dyspnea on slight exertion, and dullness over the whole chest, with weak respiration and mucous râles. There is no fever, and the appetite and strength are still good. If work is abandoned at this time, recovery is not only possible, but in most cases probable. If work is continued, the lung tissue begins to break down, and cavities form near the apices. Expectoration is very profuse, and there may be severe hemorrhages. There is general dullness on percussion, and the last traces of vesicular respiration give way to sibilant, large mucous and cavernous râles. Fever is continuous, with evening exacerbations, night sweats, emaciation, insomnia, and great dyspnea, soon followed by death.

Very suggestive also are the observations and conclusions of Dr. John Syer Bristowe, F. R. S., who, in an address on industrial diseases, read at the conference on sanitary subjects held in connection with the International Health Convention of 1884, discussed the effects of nonpoisonous irritants on the lungs, in part as follows:

> Occupations which habitually expose the workmen to the inhalation of abundant solid particles that are incapable of solution or removal by the animal tissues or secretions, in many cases induce chronic diseases of the lungs, which are known as the asthmas or consumptions of the several occupations referred to, and tend very materially to shorten life among those engaged in them. Workers in coal mines and in copper mines, grinders, millstone makers, and flax dressers are perhaps especially liable to suffer from such causes. It is marvelous how tolerant the bronchial tubes and lungs are of foreign particles which are drawn into them with the breath. Wherever smoke impregnates the atmosphere, as in London and other manufacturing towns, its particles are conveyed in greater or less abundance into the lungs; whence some are expelled with the expectoration, which presents, consequently, a slaty or black appearance, while some get absorbed, and becoming deposited in the tissue of the lungs, produce in them that black mottling which increases with advancing years, and is well known to pathologists. Yet, as a general rule, the soot-studded organs remain practically healthy, and no clinical evidences of pulmonary disease manifest themselves. The same remarks doubtless apply to the inhalation of the siliceous particles of ordinary

dust. The effects are different, however, when such matters are inhaled in large excess. * * * The symptoms under which the sufferers labor have some resemblance to those of chronic phthisis, some to those of chronic bronchitis and emphysema, for either of which they may well be mistaken. They consist in gradually increasing shortness of breath, lividity of surface, feebleness of circulation, and cough, with more or less abundant expectoration; to which, at a later period, general dropsy and hæmoptysis may be superadded. There is generally a total, or almost total, absence of fever. The only methods, so far as I know, by which the irritative diseases of the lungs just considered can be lessened or prevented, are by providing good ventilation, and (when possible) by adopting methods to prevent the diffusion of particles of dust in the atmosphere which the workmen have to breathe. It is obvious, too, that since the diseases are insidious in their progress, and increase in proportion as the inhaled particles accumulate, it would be well for persons who present early traces of them to seek at once some other kind of employment.

HARMFUL CONSEQUENCES OF INDUSTRIAL DUST EXPOSURE.

The most qualified and extended discussion of the entire subject of the inhalation of dust, its pathology and symptomatology, with special reference to dusty trades, is by Dr. J. T. Arlidge, who, in 1892, published a treatise on The Hygiene, Diseases, and Mortality of Occupations. "Few, indeed," he argued, "are the occupations in which dust is not given off," and "in none can it be absolutely harmless, for the lung tissue must be just so much the worse, and less efficient for its purpose, in proportion to its embarrassment by dust." And in continuation—

What occurs to the ordinary citizens becomes magnified ten or a hundred fold to those engaged in dusty occupations, and more especially where the dust itself possesses noxious properties. But unless dust has this latter quality, it is remarkable with what indifference its inhalation is treated by the majority of workmen. In one sense, indeed, it is unfortunate that it does not, for the most part, awaken attention by any immediate tangible consequences. Its disabling action is very slow, but it is ever progressive, and until it has already worked its baneful results upon the smaller bronchial tubes and air cells and caused difficulty of breathing, with cough and spitting, it is let pass as a matter of indifference—an inconvenience of the trade.

OBSERVATIONS ON NONTUBERCULOUS RESPIRATORY DISEASES.

Arlidge called attention to the fact that bronchitis, asthma, and pulmonary fibrosis and tuberculosis were foremost in the causes of British mortality, holding that without doubt these maladies were largely attributable to the inhalation of dust operating *per se*, or in conjunction with constitutional proclivities and insanitary surroundings. In further continuation he observes—

Pathologists tell us of the presence of bacilli in tubercular disease, and favor the belief that these minute bodies are the cause of it.

This notion may represent a whole truth or only a partial one; in my opinion, the latter. For I doubt if these bacilli actually develop phthisis unless there be some antecedent change in the vitality of the affected tissue; a change wrought by depressing causes connected with the mode of life, or with constitutional debility and inherited taint, or with the occupation followed; of which contributory factors two or more may cooperate. And assuredly the breathing of dust may be reckoned as one such of no light energy. In other words, I look upon a phthisical lung as one prepared for the germination and multiplication of bacilli, and not a primary product of those microscopic organisms, nor of the products of their organic existence.

The conclusions of Arlidge are summarized in the statement that "One practical lesson is to be gained by these considerations—namely, that *persons predisposed to respiratory diseases and phthisis ought not to engage in dusty occupations.*"

BRITISH GOVERNMENTAL INVESTIGATIONS.

More recently the subject of occupational diseases in their relation to workmen's compensation has been considered at length and in much detail by a British departmental committee appointed to consider the pressing and important question of workmen's compensation for industrial diseases. In its observations upon respiratory diseases, and in particular bronchitis, pneumonia, and phthisis, and their relation to occupation exposure, the committee concluded that—

Pulmonary disease manifests itself in three kinds or forms—as ordinary tuberculous phthisis, acute or chronic; as "fibroid phthisis," and as a mixed form when a tuberculous process is ingrafted sooner or later upon the fibroid. Fibroid phthisis is always a slow disease. It consists in a chronic reactive inflammation around the many minute foci of dust inhalation, which by coalescence gradually invades large areas, impairing and strangling the proper lung tissues in corresponding measure. Again, a lung so impaired is very apt to harbor bacilli, especially the bacillus of tubercle, by the influence of which it may be still further destroyed. Thus both fibroid phthisis uncomplicated and fibroid phthisis with the supervention of tubercle are in their nature occupational diseases.[1]

TYPICAL FORMS OF FIBROID PHTHISIS.

The committee, in its final report, describes the typical forms of fibroid phthisis as induced by the inhalation of industrial dust, holding that—

The first symptom is a cough which insidiously; and for a while almost imperceptibly, becomes habitual. At first in the morning only, it gradually becomes more frequent during the day, and expectoration, nominal at the beginning, becomes more marked, though not profuse until the latter stages of the disease. Leaving out of account the more rapid progress of the disease in tin and gold miners, these symptoms of a negative phase of purely local damage may last for years—10 or 15 or even more—without advancing to such a degree as to throw the workman out of employment or even to cause him serious inconvenience. At some period, however, rarely less than 10 years and frequently more than 20, of continuous employment, in a like imperceptible manner the breathing gets shorter and the patient finds himself less and less capable of exertion. Yet, even when the cough and dyspnea have reached a considerable degree, there are no signs of fever, as is the case of pulmonary tuberculosis; the flesh does not fall and the muscles retain their strength and volume. Thus even at a period when the malady is fully established the general health may be but little impaired, and the patient may not be compelled to cease work. Herein fibroid phthisis presents a well-marked difference from pulmonary tuberculosis; and even if, as we have said, the disease becomes complicated with tubercle, yet the rate of progress may be determined rather by the character of the primary than of the secondary disease, though usually the supervention of tubercle hastens the sufferer into a more rapid consumption.[1]

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[1] Report of the Departmental Committee on Compensation for Industrial Diseases, London, 1907, p. 13.

The results of all these researches into an almost neglected field of preventive medicine prove that occupation diseases, properly so called, demand the most thoroughly qualified medical supervision of factories and workshops and the periodical medical examination and inspection of persons employed in recognized unhealthy trades. For, as the committee referred to points out, "If in the early stage of fibroid phthisis the workman leaves the dusty employment for work in agriculture or in other occupation in air free from irritating particles, the disease may be practically arrested; that is, although the part affected may proceed to obliteration, the disease would not extend to other parts of the lung, and the portion destroyed would be negligible as a factor of health and capacity."[2]

FIBROID PHTHISIS AND OCCUPATIONAL DISEASE.

The conclusion of this investigation, the most important official inquiry ever made into the subject of industrial diseases, fully warrants the view that while ordinary tuberculous phthisis can not be regarded as a disease peculiar to any occupation, fibroid phthisis in its latter stage, and when the history of the case is known, can be clearly distinguished from tuberculous phthisis; so that it may be regarded as an established fact that fibroid phthisis is a disease peculiar to employment in certain trades, of which the committee mentions the following: Grinders continuously using either grindstones or emery for the abrasion of metals, especially steel; potters engaged in certain processes; stone workers employed on certain kinds of stone, especially if not working in the open air; tin miners, in particular such as have previously been exposed to the exceedingly unhealthy conditions of the gold mines of the Transvaal; and ganister miners, including men employed in certain processes of ganister brickmaking. The committee did not arrive at final conclusions regarding persons employed in the slate industry, or employees in the working of asbestos and many other recognized unhealthy trades, partly, no doubt, because of the limited scope of the inquiry and the paucity of conclusive statistical data. It is pointed out by the committee that it was not possible to separate the English death rates for fibroid phthisis from those for other diseases of the respiratory system, since medical men do not, as a rule, distinguish that disease when certifying the causes of death. It is clearly established by the results of the investigation that such a distinction should be made and that medical practitioners should qualify the death returns from tuberculosis in all cases where the death was the result of fibroid phthisis.

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[1] Report of the Departmental Committee on Compensation for Industrial Diseases, 1907, p. 13.

[2] Idem, p. 14.

The committee, having arrived at the opinion that fibroid phthisis is a specific and distinguishable trade disease, concluded that employers might properly be required to pay compensation to their workpeople who contract it; but it did *not*, however, recommend the extension of the workmen's compensation act to the disease for two reasons. The first was that, owing to the long period of its development, it would not be right to lay the whole burden on the employer under whom the workman had been serving during the 12 months prior to the incapacity. The other and even more important reason was that for several years before the nature of the disease can be definitely diagnosed the patient may suffer from symptoms that, while not distinctive, are sufficient to prevent him from securing employment.

In the brief descriptive account of 118 industries and occupations considered in detail in this discussion only the most general facts have been included in order to emphasize, as far as possible, the industrial processes productive of conditions more or less injurious to health in general, and conducive to the development of tuberculosis in particular. Authorities are referred to only so far as this has seemed necessary to establish clearly, in the case of each trade or occupation considered, the facts of a more or less excessive degree of frequency of pulmonary tuberculosis, aside from the statistical sources of information which form the basis of the subsequent conclusions, except in the case of a few employments for which neither general vital statistics nor insurance mortality experience are as yet available. The term "tuberculosis" is used in a very general sense, but as a rule limited to phthisis pulmonalis, or pulmonary tuberculosis, unless otherwise stated. All of the references to insurance mortality experience are limited to the mortality from phthisis pulmonalis and do *not* include that from other forms of tuberculosis or other forms of respiratory diseases unless specifically stated in the text.

SOURCES OF STATISTICAL INFORMATION.

The principal statistical data utilized in the present discussion are the following: First, the occupation returns according to age and sex as published in 1914 by the Thirteenth United States Census for the year 1910; second, the occupation mortality statistics of the Twelfth Census, published in 1904; third, the occupation mortality data published in the annual reports on the mortality of the United States registration area for the years 1908 and 1909; fourth, the occupation mortality statistics published decennially as a supplement to the Report of the Registrar-General of Births, Marriages, and Deaths for England and Wales for the two periods, 1890–1892 and 1900–1902 (no later data have as yet been published); fifth, the corresponding decennial mortality statistics of Scotland; sixth, the industrial mortality statistics of the Prudential Insurance Co. of America for the period 1897 to 1914, published in connection with the company's exhibits at the British Congress on Tuberculosis, 1901, the Louisiana Purchase Exposition, 1904, the International Congress on Tuberculosis, 1908, the International Congress on Hygiene and Demography, 1912, and the Panama-Pacific International Exposition, 1915; seventh, the industrial mortality statistics of the Metropolitan Life Insurance Co., presented at the annual meeting of the American Public Health Association, 1915; and eighth, miscellaneous occupation mortality statistics derived from special sources or made public in connection with local investigations, including, among others, medico-actuarial experience data, the mortality returns for the textile industry of Blackburn, England, the cutlery industry in Sheffield, England, the quarry industry of Derbyshire, England, the stone industry of Aberdeen, Scotland, the mining industry of Cornwall, South Africa, Montana, southwest Missouri, etc.

PRINCIPLES OF STATISTICAL ANALYSIS.

At least four different statistical methods are available for the purpose of determining with approximate accuracy the degree of tuberculosis frequency in different trades or specified occupations. Absolute accuracy is not obtainable in investigations of this kind, nor is this absolutely essential for the practical ends in view.

The first method is to determine the proportion of persons in specified occupations living at ages 65 and over, and to compare the same with the corresponding proportion for occupied males generally. This method is never conclusive by itself, but is occasionally useful in connection with the use of other statistical data. It is self-evident that other factors besides mortality determine the proportion of persons in different occupations at ages 65 and over. It has been shown, for illustration, by the census of 1910, that of the male population, ages 14 to 44, the proportion employed in gainful occupations is 89.3 per cent, in contrast with only 28.6 per cent for the female population. The proportion employed in the general population varies materially according to sex and age, there being a gradual increase from ages 14 to about 45, subsequent to which the proportion either unemployed for physical or retired for economic reasons gradually increases. At ages 21 to 44, for illustration, in the American population 96.7 per cent of the males but only 26.3 per cent of the females are employed in gainful occupations. The maximum proportion of employed among women occurs at ages 16 to 20, when 39.9 per cent are engaged in gainful occupations.

In the general population, ages 10 years and over, according to the census of 1910, 81.3 per cent of males and 23.4 per cent of females were engaged in gainful occupations. The corresponding percentages in 1900, according to the census, were 80 for males and 18.8 for females. The proportions for the aggregate employees in the principal occupations with exposure to dust, according to the census of 1910, are shown in Table 3.

TABLE 3.—AGE DISTRIBUTION OF PERSONS IN GAINFUL OCCUPATIONS WITH EXPOSURE TO INDUSTRIAL DUSTS.

[Compiled from Report of Bureau of the Census on Occupation Statistics, 1910. For occupations included, see pp. 46 to 50.]

Age group.	Males.		Females.	
	Number.	Per cent.	Number.	Per cent.
10 to 13 years	11,817	0.4	8,211	1.2
14 to 15 years	64,110	2.0	55,671	8.3
16 to 20 years	435,105	13.3	251,477	37.3
21 to 44 years	2,094,694	64.2	308,130	45.8
45 years and over	658,774	20.1	49,989	7.4
Total, 10 years and over	3,264,500	100.0	673,478	100.0

By way of further illustration attention may be directed to the fact that of 5,606,789 farmers 2,457,572, or 43.8 per cent, were 45 years and over. In contrast, out of 210,566 males employed in cotton mills only 34,476, or 16.4 per cent, were 45 years and over. It, of course, would be quite erroneous to conclude that the differences in percentages measure the full effect of an excessive mortality, since for obvious reasons the age distribution is primarily determined by occupational requirements and conditions. The illustration is sufficient for the purpose of emphasizing the practical limitations of the method of ascertaining occupational mortality by means of the proportion of persons living at advanced ages in specified employments.

The second method is to ascertain the average age at death in particular occupations from all and specified causes. This method was quite extensively employed in the earlier registration reports for certain New England States, and while occasionally useful in connection with other data the method by itself is frequently seriously misleading. According to the combined statistics for the State of Rhode Island (1852–1910), the average age at death of farmers was 67.4 years, against 55.86 years for florists. There are no reasons for believing that on the average florists experience a higher death rate than farmers and certainly not to the extent indicated by the difference of 11.5 years in the average age at death. Another interesting illustration is the high average age at death of clergymen, given according to the Rhode Island experience[1] as 63.78 years, and the very low average age at death of electricians, given as 36.14 years. These illustrations are sufficient for the purpose of emphasizing the uselessness and misleading character of a method still occasionally employed in determining the relative mortality in different occupations from all causes or special causes by means of the average age at death.

The third method is to determine the exact mathematical rate of mortality from all causes or specific causes, such as tuberculosis or industrial accidents, by the ascertainment of the number of deaths occurring among every 1,000 persons of any particular trade or occupation exposed to risk of death for a given period of time, usually a single year. This method is probably the most satisfactory; but it is often quite impossible to secure strictly accurate information regarding the number of persons employed in particular trades or occupations and the corresponding number of deaths in precisely the same group of employments. *Estimates* of the numbers exposed to risk in particular occupations are quite likely to be seriously misleading, and the chance of error is materially increased by differences in the prevailing methods of occupation classification. It is rarely the case that both the census enumeration and the occupation mortality returns are ascertained in *exactly* the same manner by the census and the health authorities or registration officials throughout the country.

The fourth method is to determine the exact proportion of deaths from a specific cause, such as pulmonary tuberculosis, occurring in the mortality from all causes, without reference to ages at death. When this method is used with the required caution, the proportions thus determined are often sufficiently suggestive of abnormal conditions and occasionally conclusive.

A fifth method is a modification of the fourth and is generally known as the proportionate mortality figure, by means of which the proportion of deaths from any particular disease, such as pulmonary tuberculosis, is calculated as a percentage of the deaths from all causes occurring during specified periods of life. This method has been extensively employed in the present discussion, since otherwise the available industrial insurance mortality statistics could not have been fully utilized. This method, in a measure, is, however, the most satisfactory and practically conclusive, since it presents with approximate accuracy the true proportionate incidence of pulmonary tuberculosis or the degree of its frequency at specified periods of life.

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[1] Fifty-eighth Registration Report, Rhode Island, 1910, p. 631 et seq.

INDUSTRIAL INSURANCE MORTALITY STATISTICS.

The industrial insurance mortality statistics utilized in the present discussion are derived largely from the experience of two thoroughly representative companies which have from time to time given publicity to the facts of their experience. The resulting proportionate mortality returns, however, indicate a specific mortality from pulmonary tuberculosis somewhat below the actual, since the experience is, to a certain extent, modified by medical selection; in other words, the proportionate mortality from pulmonary tuberculosis, or the true, actual loss from the disease at specified age periods would have been somewhat higher if medical selection had not been made use of. In comparing this experience with the corresponding standard for the registration area of the United States the comparison is, therefore, somewhat more favorable to the various trades and occupations considered than would have been the case if the returns could have been derived from the registration records of the different States and cities comprehending the experience of the companies referred to.

Of the aggregate number (34,997,474) of industrial policies in force with all American industrial companies on December 31, 1916, the proportion in force with the Prudential and Metropolitan companies was 84 per cent. The experience utilized, therefore, may be considered as thoroughly representative for the industrial population of the country at large.

THE PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS.

The proportionate mortality figures may briefly be explained as follows: At ages 25 to 34, out of every 100 deaths from all causes in the registration area of the United States during the 14 years ending in 1913, 30.5 deaths were from pulmonary tuberculosis. The corresponding proportion of deaths in the industrial insurance mortality experience of the Prudential Co. was 67.9 per cent for grinders, 55.9 per cent for printers and compositors, 53 per cent for upholsterers, 45.3 per cent for potters, etc. The difference between the average mortality from pulmonary tuberculosis for the registration area as a whole and the corresponding proportionate mortality from pulmonary tuberculosis in the occupations considered in some detail, measures approximately the health-injurious circumstances for different employments. It, however, does not follow that all of the difference is necessarily or specifically attributable to the employment as such, or to the health-injurious conditions under which the industry may be carried on.

DESCRIPTIVE DEFINITIONS OF INDUSTRIAL DUSTS.

Preliminary to the analysis of the mortality data and the observations having reference to the specific occupations or employments considered, the following descriptive definitions of industrial dusts, by Charles Baskerville, Ph. D., are included in explanation of the statistical data and groupings of occupations with exposure to industrial dust. The extract is from an exceptionally useful and trustworthy dissertation on "Air impurities: dust, fumes, and gases," in the New York Medical Journal, November 23 and 30, 1912.

First, as regards *insoluble inorganic dusts*, it is said that "this class includes metals (antimony, arsenic, type metal, brass, bronze, copper, aluminum, iron, steel, lead, manganese, vanadium and ferrovanadium, silver, tin, zinc, and solder) in a state of fine division (dusts, atomized metals, metallic powders); flue dusts; various ore dusts (iron ore, etc.); silica, sand, emery, flint, glass powders; carbon graphite, diamond, coal, soot; brick dust, marble, granite, cement, terra cotta; lime, gypsum, plaster, meerschaum; phosphates, guano, etc." The continuous and considerable exposure to the inhalation of insoluble inorganic dusts, according to Baskerville (who is sustained by numerous other authorities) may result in fibrosis of the lungs, chiefly because of the inhalation of siliceous or metallic particles, as, for example, is the case in the so-called potters' asthma and grinders' phthisis. Pneumonia has been reported as frequent among workmen in blast furnaces, owing, in part, directly or indirectly, to the inhalation of slag dust. The disease known as siderosis is commonly met with among metal polishers, knife grinders, and others engaged in metal working.

Second, *soluble inorganic dusts.*—This class, according to Baskerville, includes such substances as are likely to be swallowed and absorbed, as, for illustration, metal particles, including lead, brass, copper, zinc, arsenic, mercury, and silver, as well as soluble inorganic salts. Many dusts of this class, it is pointed out, "are dangerous not only because of their irritating or poisonous properties, but also because of their inflammability, e. g., potassium chlorate."

Third, organic dusts.—This class is defined as comprising such widely varying materials as "sawdust, fur, skins, feathers, broom and straw, grains and flours, jute, flax, hemp, cotton, wool, carpet dust, street sweepings, tobacco-box dust, hides and leather, felts, rags, paper, horsehair, etc." Typical of the diseases caused by organic dusts are: "Flax dressers' disease, a kind of pneumonia due to the inhalation of particles of flax; pneumoconiosis due to the inhalation of dust by ganister workers; alkaloidal poisoning from African boxwood by workmen engaged in shuttle making; and malignant pustule and a febrile disease among rag sorters."

THE CLASSIFICATION OF DUSTY TRADES.

The occupational grouping adopted for the purposes of the present discussion is necessarily a more or less arbitrary one, since all employments involve exposure to more than one particular kind of dust. It is, however, safe to assume that the predominating characteristic of a particular kind of dust exposure primarily determines the resulting departure of the mortality from pulmonary tuberculosis from the normal for the general population. All the groupings of dusty trades which have been adopted by Benoiston de Chateauneuf, in Oesterlen's Medical Statistics,[1] by Hirt, Sommerfeld, Merkel, Arlidge, Oliver, and others have this limitation in common, since no entirely conclusive scientific investigation has been made to afford the material for a final and strictly scientific classification of dusty trades. The present classification, however, will at least serve the purpose of a convenient arrangement, with a strict regard to the facts as they are known and understood at the present time.

The occupational grouping as given below has been adopted to emphasize in a rather general way the principal dust hazards in 118 occupations or groups of employments, and to facilitate the convenient reference to the particular industries considered in more or less detail in the subsequent discussion.

INDUSTRIAL AND OCCUPATIONAL CLASSIFICATION ACCORDING TO THE KIND OF UNAVOIDABLE DUST EXPOSURE, WITH SPECIAL REFERENCE TO THE MORTALITY FROM PULMONARY TUBERCULOSIS.

SECTION A.—INORGANIC DUSTS.

Group 1.—Metallic dust.

Artificial-flower makers.
Brass workers.
Chippers, at blast furnaces and steel rolling mills.
Compositors and typesetters.
Cutlery makers.
Die setters and sinkers.
Electrotypers and stereotypers.
Engravers.
Filers.
Gold beaters.
Grinders.

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[1] Handbuch der medicinischen Statistik, by Dr. Fr. Oesterlen, Tübingen, 1874, p. 389.

Grinders, card (cotton mills).
Jewelers. manufacturing.
Polishers, buffers, and finishers.
Pressmen and press feeders.
Sand blasters.
Saw filers.
Solderers.
Toolmakers.

Group 2.—Mineral dust.

Asbestos workers.
Brick, tile, and terra-cotta factories.
Core makers.
Color mixers.
Glass blowers.
Glass factories (other than blowers).
Lacquerers, japanners, enamelers.
Lime, cement, and gypsum factories.
Lithographers.
Marble and stone workers.
Mica workers.
Mirror makers.
Molders.
Paint factories.
Paper hangers and helpers.
Plasterers.
Potteries.
Whitewashers.

Group 3.—Mineral industries.

Asphalt miners.
Bauxite miners.
Coal miners.
Copper miners.
Gold and silver miners.
Graphite miners.
Iron miners.
Lead and zinc miners.
Mica miners.
Phosphate miners.
Quarries.
Quicksilver miners.
Spar miners.
Sulphur miners.
Other and not specified miners.

SECTION B.—ORGANIC AND MISCELLANEOUS DUSTS.

Group 4.—Vegetable fiber dust.

Broom and brush factories.
Corn shellers, grain thrashers, wood sawyers, etc., in agriculture.
Cotton ginners.
Cotton spinners.
Cotton weavers.
Other cotton mill employees.
Hay and straw balers.
Hemp and jute mills.
Knitting mills.
Lace and embroidery.
Linen mills.
Paper and pulp mills.
Paper-box makers.
Rag dealers.
Rag pickers, sorters, and cleaners.
Rope and cordage factories.
Sail, awning, and tent factories.
Straw factories.
Textile mills—dyeing, finishing, printing.
Textile mills (not specified).
Wood—cabinetmakers.
Wood—box makers.
Wood carvers.
Wood—furniture factories, except polishers and finishers.
Wood—piano and organ factories, except polishers and finishers.
Wood polishers and finishers.
Wrappers and packers.

Group 5.—Animal and mixed fiber dust.

Carpet mills.
Furriers.
Hair workers.
Hat factories.
Mattress makers.
Upholsterers.
Silk mills.
Woolen and worsted spinners.
Woolen and worsted weavers.
Woolen and worsted mills.

Group 6.—Organic dust.

- Bakeries.
- Bone and ivory workers.
- Button factories.
- Candy factories.
- Celluloid workers.
- Charcoal and coke works.
- Cigar and tobacco factories.
- Fertilizer factories.
- Glove factories.
- Grain and flour mills.
- Grain-elevator employees.
- Harness and saddle factories.
- Pocketbook and belt makers.
- Rubber factories.
- Shoe factories.
- Shoemakers (not in factories).
- Tanneries.
- Trunk factories.

Group 7.—Mixed organic and inorganic (public) dusts.

- Carriage and hack drivers.
- Chauffeurs.
- Coachmen.
- Drivers and teamsters.
- Garbagemen and scavengers.
- Street car conductors.
- Street car motormen.
- Street cleaners.
- Sweepers, car.
- Waste products (junk).

AGE IN RELATION TO OCCUPATION AND DUST EXPOSURE.

For convenience and ready reference the so-called dusty industries, trades, and occupations have been arranged in seven large groups, which include specific subgroupings and an aggregate of 3,264,500 males and 673,478 females, as returned by the occupation census of 1910. The grouping in matters of detail is unquestionably open to criticism, but in the absence of a thoroughly worked out descriptive account of the industries, trades, and occupations referred to it is exceedingly difficult to adopt a more satisfactory arrangement. Since each subgrouping will be discussed in detail, the errors inherent in the main groupings are not, as a matter of practical certainty, of sufficient importance to invalidate the final conclusions concerning the specific injuriousness of particular forms of dust. Since the age distribution of wage earners in particular occupations varies widely, the details according to sex and for all the seven subdivisions are given in Table 6 (pp. 46 to 50), included in which is a column showing for each and every industry, trade, or occupation the proportion living at ages 45 and over. The wide differences in age distribution disclosed by this analysis are of special importance in the scientific consideration of the mortality data and the descriptive observations concerning the conditions under which the various dusty trades are carried on. The same conclusion applies to differences in the sex distribution of employees; for, as elsewhere shown, the specific death rates from tuberculosis vary considerably, according to age and sex. For illustration, at ages 15 to 24 the mortality from tuberculosis of the lungs is 12.15 per 10,000 for males, against 14.15 per 10,000 for females; in other words, the normal tuberculosis mortality of females is excessive at this period of life. If, therefore, an industry, trade, or occupation includes a disproportionately large number of young women wage earners, the general mortality from tuberculosis might be higher without necessarily implying a very definite relation to the more or less considerable degree of dust exposure.

Conceding the general untrustworthiness of morbidity and mortality conclusions based exclusively upon the age distribution of persons employed in different industrial groups according to the kind of dust exposure, some value may safely be attached to this method of analysis when made use of with exceptional caution on account of the large variety of special conditions and circumstances which have an important bearing upon the age distribution of men and women in different industrial pursuits. Some employments are obviously only for the young, while others are chiefly for the old. In some no special trade ability is required, with the result that there are frequent occupation changes, while in other groups the required degree of specialized skill is such that the employment becomes practically the pursuit of a lifetime. Furthermore, in certain occupations there is a constant elimination of employees with advancing age on account of unsuitability for the special industrial pursuits carried on, which, of course, tends materially to disturb the proportion of aged persons under the conditions stated.

AGE DISTRIBUTION OF EMPLOYEES IN DUSTY TRADES.

Table 4 shows the proportionate distribution of males in the seven groups of dusty trades according to three subdivisions of age—under 16, from 16 to 44, and 45 and over. It is most regrettable that the census age grouping by occupation should not have been extended to the age period 65 and over, which, of course, for certain morbidity and mortality purposes is distinctly more useful and conclusive than the age period of 45 and over:

TABLE 4.—PROPORTIONATE AGE DISTRIBUTION OF MALES IN DUSTY TRADES.

[Compiled from Report of Bureau of the Census on Occupation Statistics, 1910. For occupations included, see pp. 46 to 50.]

Trade groups.	Per cent in age group—		
	Under 16.	16 to 44.	45 and over.
1. Metallic dust	0.54	82.52	16.94
2. Mineral dust	1.86	78.43	19.71
3. Mineral industries	1.74	79.65	18.61
4. Vegetable fiber dust	7.73	75.01	17.26
5. Animal and mixed fiber dust	4.06	75.49	20.45
6. Organic dust	2.28	72.53	25.19
7. Mixed organic and inorganic (public) dusts	.77	77.91	21.32
Total	2.33	77.49	20.18

According to this table, the proportion of young persons is largest in the group of occupations with exposure to vegetable fiber dusts, which, of course, is inclusive of the entire cotton-textile industry. The proportion is least in the group of occupations with exposure to metallic dusts, largely because of the practical absence of an apprentice system and the highly specialized skill required of a large number of employees in the cutlery, tool, jewelry, printing, and related trades. In the entire group of dusty trades the proportion of men aged 45 and over is 20.18 per cent, being lowest among the workers with exposure to metallic dusts, or 16.94 per cent, and highest among workers with exposure to organic dusts, or 25.19 per cent. This result is of special significance in the case of men employed with exposure to metallic dusts, on account of the small proportion employed at ages under 16, which ordinarily, of course, would tend to raise the proportion at ages 45 and over. The abnormal age distribution in the case of this group of employees, therefore, confirms the mortality data suggestive of an excessive death rate among men employed in this group of occupations, particularly or largely in consequence of considerable and continuous exposure to metallic dusts. In the case of men employed in occupations with exposure to vegetable fiber dusts the proportion aged 45 and over is 17.26 per cent, but this low proportion is in part due to the very high proportion of persons employed at ages under 16. Here, however, also to a limited extent the high figure is fairly conclusive and indicative of a relatively high mortality in middle adult life. The group of occupations following, in the order of the proportion of persons aged 45 and over, is composed of men employed in mineral industries, followed by men employed in occupations with exposure to mineral dusts, which two groups, of course, have much in common, and for which the age distribution is almost the same. A more favorable proportion is shown for persons employed in occupations with exposure to animal and mixed fiber dusts, or 20.45 per cent, and these are followed by persons with exposure to public or street dusts (21.32 per cent), and, finally, by persons in the group of occupations with exposure to organic dusts, or 25.19 per cent. As shown elsewhere, in this group of occupations the result of dust exposure is apparently least harmful where the proportion of workers 45 years and over is correspondingly the largest. In a general way, therefore, the age distribution fairly conforms to the conclusion based upon mortality statistics.

Table 5 exhibits the corresponding information for females, but the data must be considered distinctly less conclusive and, in the case of certain groups, practically valueless, on account of the small number of employees concerned.

TABLE 5.—PROPORTIONATE AGE DISTRIBUTION OF FEMALES IN DUSTY TRADES.

[Compiled from Report of Bureau of the Census on Occupation Statistics, 1910. For occupations included, see pp. 46 to 50.]

Trade group.	Per cent in age group—		
	Under 16.	16 to 44.	45 and over.
1. Metallic dust	4.27	90.50	5.23
2. Mineral dust	7.99	85.26	6.75
3. Mineral industries	7.27	80.91	11.82
4. Vegetable fiber dust	11.94	81.75	6.31
5. Animal and mixed fiber dust	8.44	82.20	9.36
6. Organic dust	7.45	84.55	8.00
7. Mixed organic and inorganic (public) dusts	1.00	78.20	20.80
Total	9.50	83.10	7.40

No safe deductions can be based upon this table, which is merely included here for the purpose of completeness. The chief factor of uncertainty inherent in this table is the constant elimination of women from industry on account of marriage and for other reasons, naturally tending toward a decidedly lower proportion of women ages 45 and over in industrial pursuits, regardless of the fact that in the population at large the proportion of women at this period of life exceeds the corresponding proportion of men. Even subject to these qualifications it is suggestive that the proportion of women aged 45 and over employed in occupations with exposure to metallic dusts should be the lowest of the seven groups, 5.23 per cent, against 7.40 per cent for the aggregate number of female employees in occupations with exposure to industrial dusts. There are practically no women employed in mineral industries, but as shown by the introductory tables most of the occupied females are employed in the occupations with exposure to vegetable fiber dusts, animal and mixed fiber dusts, and organic dusts, which are, of course, inclusive of all the different subdivisions of the textile industry. It is suggestive in this connection that no definite conclusions can be drawn from the table further than as stated.

The analysis could have been extended to the 118 individual occupations, employments, or industries, but the table following makes this unnecessary. The details, however, in the case of many occupations are distinctly indicative of unfavorable health conditions, and especially is this true for grinders, polishers, and buffers, toolmakers, and sand blasters in the iron and steel industries. An analysis in detail, however, is much more subject to the qualification of extreme care in the use of the data for the purpose of emphasizing the possibly injurious results of any particular occupation, industry, or trade on the basis of the proportion of men or women employed at ages 45 and over. The data are included primarily for the purpose of making the statistics conveniently available, and to bring the facts of age distribution into intelligent correlation to the general discussion of the circumstances and conditions more or less accountable for health-injurious results of certain occupations, trades, and industries by reason of the approximately ascertainable exposure to different kinds of industrial dust.

TABLE 6.—AGE DISTRIBUTION OF EMPLOYEES IN DUSTY TRADES, BY SEX AND OCCUPATION GROUPS.

Compiled from Report of Bureau of the Census on Occupation Statistics, 1910.]

GROUP 1.—METALLIC DUST.

Sex and occupation group.	Total employees.	Number in age group—					Per cent 45 years and over.
		10 to 13.	14 to 15.	16 to 20.	21 to 44.	45 and over.	
MALE.							
Artificial-flower makers	1,238	7	57	267	672	235	19.0
Brass workers	15,912	....	82	1,665	11,166	2,999	18.8
Chippers (blast furnace and steel rolling mill)	968	....	3	62	722	181	18.7
Compositors and typesetters	111,489	4	23	21,902	70,726	18,834	16.9
Cutlery makers	4,840	5	107	889	2,894	945	19.5
Die setters and sinkers	2,741	....	4	290	1,996	451	16.5
Electrotypers and stereotypers	4,268	....	1	510	3,097	660	15.5
Engravers	11,315	....	27	1,850	7,574	1,864	16.5
Filers	3,016	1	31	320	1,769	895	29.7
Gold beaters	607	....	12	103	327	165	27.2
Grinders	8,214	....	93	1,070	5,346	1,705	20.8
Grinders, card	1,087	....	1	66	726	294	27.0
Jewelers, manufacturing	6,943	....	11	1,243	4,257	1,432	20.6
Polishers, buffers, and finishers	31,772	4	401	4,241	21,759	5,367	16.9
Pressmen and press feeders	25,951	15	437	6,851	16,677	1,971	7.6
Sand blasters, iron and steel	99	....	....	20	65	14	14.1
Saw filers	7,345	....	2	387	4,910	2,046	27.9
Solderers	434	....	3	97	278	56	12.9
Toolmakers	20,212	....	75	2,282	14,186	3,669	18.2
Total	258,451	36	1,370	44,115	169,147	43,786	....
Per cent in each age group	100.00	0.01	0.53	17.07	65.45	16.94	....
FEMALE.							
Artificial-flower makers	8,616	50	919	3,791	3,297	559	6.5
Brass workers	187	....	4	82	88	13	7.0
Compositors and typesetters	13,681	....	7	4,567	8,411	696	5.1
Cutlery makers	543	....	39	263	218	23	4.2
Die setters and sinkers	4	....	....	2	2	....	....
Electrotypers and stereotypers	100	....	1	27	62	10	10.0
Engravers	451	....	2	158	268	23	5.1
Filers	227	....	4	100	111	12	5.3
Gold beaters	76	....	2	32	35	7	9.2
Grinders	364	....	11	189	157	7	1.9
Grinders, card	4	....	....	1	3	....	....
Jewelers, manufacturing	1,435	....	23	550	789	68	4.7
Polishers, buffers, and finishers	3,204	1	176	1,269	1,577	181	5.6
Pressmen and press feeders	4,133	....	174	1,863	1,962	131	3.2
Sand blasters, iron and steel	2	....	....	2	....	....	....
Saw filers	2	....	....	....	2	....	....
Solderers	161	....	2	73	85	1	.6
Toolmakers	65	....	....	16	44	5	7.7
Total	33,255	51	1,369	12,985	17,111	1,739	....
Per cent in each age group	100.00	0.15	4.12	39.05	51.45	5.23	....

GROUP 2.—MINERAL DUST.

MALE.							
Asbestos workers	1,197	2	15	121	891	168	14.0
Brick, tile, and terra-cotta factories	92,823	566	2,112	14,663	59,862	15,620	16.8
Core makers	16,479	4	411	4,019	10,638	1,377	8.4
Color mixers (not paint)	858	....	15	114	512	217	25.3
Glass blowers	15,471	....	17	957	11,885	2,615	16.9
Glass factories (excluding blowers)	61,299	395	4,104	14,416	34,135	8,249	13.5
Lacquerers, japanners, enamelers	1,225	....	23	174	811	217	17.7
Lime, cement, and gypsum factories	46,898	78	414	5,573	33,340	7,493	16.0
Lithographers	7,661	....	11	1,299	5,001	1,350	17.6
Marble and stone yards	52,813	23	278	4,138	33,731	14,643	27.7
Mica workers	27	....	1	10	14	2	7.4
Mirror makers	687	1	8	100	482	96	14.0

TABLE 6.—AGE DISTRIBUTION OF EMPLOYEES IN DUSTY TRADES, BY SEX AND OCCUPATION GROUPS—Continued.

GROUP 2.—MINERAL DUST—Concluded.

Sex and occupation group.	Total employees.	Number in age group—					Per cent 45 years and over.
		10 to 13.	14 to 15.	16 to 20.	21 to 44.	45 and over.	
MALE—concluded.							
Molders	113,617	....	37	8.165	81,070	21,345	18.8
Paint factories	4,727	4	91	730	3,010	892	18.9
Paper hangers, apprentices, and helpers	25.561	14	255	2,362	16.636	6,294	24.6
Plasterers	50.525	18	147	3,452	30,561	16,344	32.3
Potteries	21.159	44	488	3,578	13,397	3,652	17.3
Whitewashers	1,663	1	4	65	696	897	53.9
Total	514.693	1,150	8,431	63.966	339.675	101,471	....
Per cent in each age group	100.00	0.22	1.64	12.43	66.00	19.71	....
FEMALE.							
Asbestos workers	129	....	21	55	47	6	4.7
Brick, tile, and terra-cotta factories	1,581	8	135	613	711	114	7.2
Core makers	1,836	....	90	1,016	708	22	1.2
Color mixers (not paint)	37	....	3	23	10	1	2.7
Glass blowers	90	....	2	39	45	4	4.4
Glass factories (excluding blowers)	3,874	33	451	1,957	1,338	95	2.5
Lacquerers, japanners, enamelers	289	1	17	140	120	11	3.8
Lime, cement, and gypsum factories	281	....	9	87	146	39	13.9
Lithographers	477	....	1	222	238	16	3.4
Marble and stone yards	224	1	22	85	96	20	8.9
Mica workers	164	....	6	119	36	3	1.8
Mirror makers	33	....	2	10	19	2	6.1
Molders	66	....	2	20	35	9	13.6
Paint factories	213	3	21	109	70	10	4.7
Paper hangers, apprentices, and helpers	823	....	4	18	466	335	40.7
Plasterers	8	....	....	....	4	4	50.0
Potteries	5,202	16	377	2,030	2,438	341	6.6
Whitewashers	5	....	....	....	2	3	60.0
Total	15,332	62	1,163	6.513	6,529	1,035	....
Per cent in each age group	100.00	0.40	7.59	42.68	42.58	6.75	....

GROUP 3.—MINERAL INDUSTRIES.

Sex and occupation group.	Total employees.	10 to 13.	14 to 15.	16 to 20.	21 to 44.	45 and over.	Per cent 45 years and over.
MALE.							
Asphalt miners and laborers	132	2	1	14	106	9	6.8
Bauxite miners and laborers	200	....	2	36	128	34	17.0
Coal miners	591,024	1,292	11,319	73,514	402,631	102,268	17.3
Copper miners	35,117	16	86	2.632	27,034	5,349	15.2
Gold and silver miners	53,869	5	43	2,154	32,915	18,752	34.8
Graphite miners and laborers	178	1	2	19	134	22	12.4
Iron miners	45,917	152	427	5,681	34,189	5,468	11.9
Lead and zinc miners	18,526	4	100	2,093	13,363	2.966	16.0
Mica miners and laborers	277	3	8	45	169	52	18.8
Phosphate miners and laborers	4.582	80	131	665	3,201	505	11.0
Quarries	73,954	118	815	9,029	49,097	14,895	20.1
Quicksilver miners and laborers	126	....	....	3	88	35	27.8
Spar miners and laborers	501	10	14	68	330	79	15.8
Sulphur miners and laborers	485	1	1	78	338	67	13.8
Mines not specified	19.117	15	55	973	11,561	6,513	34.1
Other miners and laborers	892	4	16	119	549	204	22.9
Total	844,897	1,703	13,020	97.123	575,833	157.218	....
Per cent in each age group	100.00	0.20	1.54	11.50	68.15	18.61	....
FEMALE.							
Bauxite miners and laborers	1	....	....	....	1	....	....
Coal miners	368	2	27	94	214	31	8.4
Copper miners	15	....	....	....	12	3	20.0
Gold and silver miners	39	....	....	....	19	20	51.3
Iron miners	32	....	3	8	17	4	12.5
Lead and zinc miners	14	....	1	5	8	....	....
Mica miners and laborers	29	1	3	13	10	2	6.9
Phosphate miners and laborers	11	....	....	1	9	1	9.1
Quarries	28	....	....	8	18	2	7.1
Spar miners and laborers	1	....	....	....	1	....	....
Other miners and laborers	12	2	1	1	6	2	16.7
Total	550	5	35	130	315	65	....
Per cent in each age group	100.00	0.91	6.36	23.64	57.27	11.82	....

TABLE 6.—AGE DISTRIBUTION OF EMPLOYEES IN DUSTY TRADES, BY SEX AND OCCUPATION GROUPS—Continued.

GROUP 4.—VEGETABLE FIBER DUST.

Sex and occupation group.	Total employees.	Number in age group—					Per cent 45 years and over.
		10 to 13.	14 to 15.	16 to 20.	21 to 44.	45 and over.	
MALE.							
Broom and brush factories	10,563	39	370	1,825	6,096	.2,233	21.1
Corn shellers, grain thrashers, wood sawyers etc., agriculture	3,919	....	4	107	2,701	1,107	28.2
Cotton ginners, other miscellaneous industries	1,342	7	9	81	854	391	29.1
Cotton spinners	15,874	996	1,810	4,387	6,848	1,833	11.5
Cotton weavers	48,929	244	1,383	9,758	31,779	5,765	11.8
Other cotton-mill employees	80,778	4,295	8,985	18,379	38,077	11,042	13.7
Hay and straw balers	1,698	9	32	197	1,128	332	19.6
Hemp and jute mills	3,438	7	144	722	2,092	473	13.8
Knitting mills	27,236	622	2,421	7,816	13,510	2,867	10.5
Lace and embroidery	5,199	7	325	1,305	2,872	690	13.3
Linen mills	1,248	1	97	280	603	267	21.4
Paper and pulp mills	6,933	....	72	1,037	4,635	1,189	17.1
Paper-box makers	5,688	22	381	1,600	3,002	683	12.0
Rag dealers	1,805	2	9	79	952	763	42.3
Rag pickers, sorters, and cleaners	1,220	5	18	135	702	360	29.5
Rope and cordage factories	6,372	22	304	1,327	3,555	1,164	18.3
Sail, awning, and tent factories	2,604	1	34	288	1,444	837	32.1
Straw factories	205	....	9	54	115	27	13.2
Textile mills—dyeing, finishing, printing	30,382	22	692	4,459	17,949	7,260	23.9
Textile mills, (not specified)	23,800	78	1,266	4,468	12,983	5,005	21.0
Wood—cabinetmakers	7,142	....	3	405	4,069	2,665	37.3
Wood—box makers	6,382	147	432	1,690	3,143	970	15.2
Wood carvers	12,054	1	66	1,101	7,397	3,489	28.9
Wood—furniture factories, except polishers and finishers	4,146	....	120	756	2,381	889	21.4
Wood—piano and organ factories, except polishers and finishers	635	1	4	87	385	158	24.9
Wood polishers and finishers	20,271	3	224	2,324	13,360	4,360	21.5
Wrappers and packers	6,460	10	273	1,212	3,746	1,219	18.9
Total	336,323	6,541	19,487	65,879	186,378	58,038	....
Per cent in each age group	100.00	1.94	5.79	19.59	55.42	17.26	....
FEMALE.							
Broom and brush factories	2,359	4	199	1,018	1,018	120	5.1
Cotton ginners, other miscellaneous industries	39	....	....	1	29	9	23.1
Cotton spinners	32,151	3,520	5,906	13,564	8,706	455	1.4
Cotton weavers	43,911	330	2,047	11,867	25,379	4,288	9.8
Other cotton-mill employees	59,372	1,242	5,664	21,030	27,820	3,616	6.1
Hemp and jute mills	2,781	2	163	1,361	1,142	113	4.1
Knitting mills	69,414	918	7,237	28,682	28,962	3,615	5.2
Lace and embroidery	15,820	75	1,266	5,747	7,201	1,531	9.7
Linen mills	1,540	3	135	584	678	140	9.1
Paper and pulp mills	2,744	4	138	1,076	1,278	248	9.0
Paper-box makers	14,226	56	1,865	7,014	4,875	416	2.9
Rag dealers	170	....	4	32	71	63	37.1
Rag pickers, sorters, and cleaners	1,806	2	56	393	971	384	21.3
Rope and cordage factories	4,162	26	410	1,991	1,542	193	4.6
Sail, awning, and tent factories	1,074	1	44	281	590	158	14.7
Straw factories	2,378	1	77	589	1,300	411	17.3
Textile mills—dyeing, finishing, printing	4,083	10	200	1,446	2,154	273	6.7
Textile mills (not specified)	28,908	253	2,572	10,455	13,297	2,331	8.1
Wood—box makers	778	16	91	369	279	23	3.0
Wood carvers	145	....	6	45	66	28	19.3
Wood—furniture factories, except polishers and finishers	144	....	6	66	65	7	4.9
Wood—piano and organ factories, except polishers and finishers	3	....	....	2	1	....	....
Wood polishers and finishers	346	2	22	117	167	38	11.0
Wrappers and packers	7,781	25	755	4,058	2,717	226	2.9
Total	296,135	6,490	28,863	111,788	130,308	18,686	....
Per cent in each age group	100.00	2.19	9.75	37.75	44.00	6.31	....

TABLE 6.—AGE DISTRIBUTION OF EMPLOYEES IN DUSTY TRADES, BY SEX AND OCCUPATION GROUPS—Continued.

GROUP 5.—ANIMAL AND MIXED FIBER DUST.

Sex and occupation group.	Total employees.	Number in age group— 10 to 13.	14 to 15.	16 to 20.	21 to 44.	45 and over.	Per cent 45 years and over.
MALE.							
Carpet mills	19,534	22	656	3,680	11,485	3,691	18.9
Furriers	8,127	3	58	1,168	5,303	1,595	19.6
Hair workers	1,636	17	61	467	829	262	16.0
Hat factories	25,500	8	458	4,162	15,575	5,297	20.8
Mattress makers	3,202	8	65	524	2,150	455	14.2
Upholsterers	18,808	4	104	1,971	11,084	5,645	30.0
Silk mills	35,165	146	2,456	7,503	19,887	5,173	14.7
Weavers (carpets, blankets, etc., not in factories)	2,151	2	11	89	608	1,441	67.0
Woolen and worsted spinners	6,997	23	447	1,671	3,887	969	13.8
Woolen and worsted weavers	17,197	10	157	2,060	11,718	3,252	18.9
Woolen and worsted mills	45,620	106	2,650	8,502	24,534	9,828	21.5
Total	183,937	349	7,123	31,797	107,060	37,608	....
Per cent in each age group	100.00	0.19	3.87	17.29	58.20	20.45	....
FEMALE.							
Carpet mills	14,163	8	662	5,063	7,180	1,250	8.8
Furriers	2,734	....	64	921	1,458	291	10.6
Hair workers	1,894	5	187	773	624	305	16.1
Hat factories	10,735	17	563	3,631	5,425	1,099	10.2
Mattress makers	924	4	29	307	477	107	11.6
Upholsterers	1,291	....	13	318	706	254	19.7
Silk mills	52,504	283	6,098	23,027	21,495	1,601	3.0
Weavers (carpets, blankets, etc., not in factories)	10,781	57	122	976	4,098	5,528	51.3
Woolen and worsted spinners	6,390	16	806	3,550	1,883	135	2.1
Woolen and worsted weavers	14,660	14	350	3,728	9,002	1,566	10.7
Woolen and worsted mills	33,186	98	3,203	12,465	15,584	1,836	5.5
Total	149,262	502	12,097	54,759	67,932	13,972	....
Per cent in each age group	100.00	0.34	8.10	36.69	45.51	9.36	....

GROUP 6.—ORGANIC DUST.

MALE.							
Bakeries	95,026	155	1,702	14,079	61,425	17,665	18.6
Bone and ivory workers	520	1	15	98	291	115	22.1
Button factories	8,101	30	379	1,853	4,822	1,017	12.6
Candy factories	15,438	40	630	3,772	8,994	2,002	13.0
Celluloid workers	538	....	13	93	329	103	19.1
Charcoal and coke works	9,928	36	103	1,036	7,016	1,737	17.5
Cigar and tobacco factories	95,060	948	2,996	14,644	54,878	21,594	22.7
Fertilizer factories, mixers	118	....	1	12	90	15	12.7
Glove factories	5,681	5	191	1,036	3,355	1,094	19.3
Grain and flour mills	36,065	49	193	2,506	20,508	12,809	35.5
Grain elevator employees	6,484	9	35	540	4,382	1,518	23.4
Harness and saddle factories	20,271	1	103	1,736	11,027	7,404	36.5
Pocketbook and belt makers	4,842	1	119	894	3,012	816	16.9
Rubber factories	13,422	6	334	2,405	8,405	2,272	16.9
Shoe factories	104,430	97	3,051	19,141	64,097	18,044	17.3
Shoemakers (not in factories)	68,788	18	228	2,384	30,821	35,337	51.4
Tanneries	46,142	37	514	5,540	29,787	10,264	22.2
Trunk factories	1,057	5	82	255	538	177	16.7
Total	531,911	1,438	10,689	72,024	313,777	133,983	....
Per cent in each group	100.00	0.27	2.01	13.54	58.99	25.19	....
FEMALE.							
Bakeries	11,333	43	821	4,069	4,613	1,787	15.8
Bone and ivory workers	121	....	14	55	41	11	9.1
Button factories	4,707	23	468	2,269	1,805	142	3.0
Candy factories	12,553	72	1,656	6,311	4,254	260	2.1
Celluloid workers	249	....	28	124	94	3	1.2
Charcoal and coke works	12	....	....	4	3	5	41.7

TABLE 6.—AGE DISTRIBUTION OF EMPLOYEES IN DUSTY TRADES, BY SEX AND OCCUPATION GROUPS—Concluded.

GROUP 6.—ORGANIC DUST—Concluded.

Sex and occupation group.	Total employees.	Number in age group—					Per cent 45 years and over.
		10 to 13.	14 to 15.	16 to 20.	21 to 44.	45 and over.	
FEMALES—concluded.							
Cigar and tobacco factories	77,468	880	5,463	28,968	36,719	5,438	7.0
Glove factories	14,172	13	704	4,199	7,278	1,978	14.0
Grain and flour mills	396	3	20	130	188	55	13.9
Grain elevator employees	11	....	....	5	6	....	....
Harness and saddle factories	290	....	6	88	147	49	16.9
Pocketbook and belt makers	1,128	4	128	545	415	36	3.2
Rubber factories	7,955	11	488	2,853	4,257	346	4.3
Shoe factories	44,485	45	2,181	14,423	24,060	3,776	8.5
Shoemakers (not in factories)	782	....	6	148	396	232	29.7
Tanneries	1,614	4	121	749	666	74	4.6
Trunk factories	269	1	28	145	86	9	3.3
Total	177,545	1,099	12,132	65,085	85,028	14,201	....
Per cent in each age group	100.00	0.62	6.83	36.66	47.89	8.00	....

GROUP 7. MIXED ORGANIC AND INORGANIC (PUBLIC) DUSTS.

Sex and occupation group.	Total employees.	10 to 13.	14 to 15.	16 to 20.	21 to 44.	45 and over.	Per cent 45 years and over.
MALE.							
Carriage and hack drivers	57,844	166	722	6,113	36,183	14,660	25.3
Chauffeurs	44,973	5	116	8,208	34,775	1,869	4.2
Coachmen	25,171	34	159	1,534	16,379	7,065	28.1
Drivers	332,141	380	2,907	38,461	209,103	81,290	24.5
Garbagemen and scavengers	4,227	8	33	310	2,653	1,223	28.9
Street car conductors	56,932	....	4	3,573	48,174	5,181	9.1
Street car motormen	56,218	....	....	1,057	46,432	8,729	15.5
Street cleaners	9,946	2	22	270	4,571	5,081	51.1
Sweepers, car (street and steam railroad)	6,833	5	27	675	4,554	1,572	23.0
Total	594,285	600	3,990	60,201	402,824	126,670	....
Per cent in each age group	100.00	0.10	0.67	10.13	67.78	21.32	....
FEMALE.							
Carriage and hack drivers	36	....	....	6	20	10	27.8
Chauffeurs	32	1	....	3	25	3	9.4
Drivers	67	....	....	15	35	17	25.4
Sweepers, car (street and steam railroad)	1,264	1	12	163	827	261	20.6
Total	1,399	2	12	187	907	291	....
Per cent in each age group	100.00	0.14	0.86	13.37	64.83	20.80	....

CHAPTER II.—OCCUPATIONS WITH EXPOSURE TO METALLIC DUST.

THE OCCUPATIONAL MENACE OF METALLIC DUST.

The continuous and considerable exposure of workmen to the inhalation of metallic dust in its various forms is generally recognized by medical and other authorities on occupational diseases as probably the most serious health hazard with particular reference to a material increase in liability to pulmonary tuberculosis and nontuberculous respiratory diseases. The term "metallic dust" for practical reasons is for the present purpose limited to finely comminuted particles of iron, steel, brass, gold, silver, bronze, lead, arsenic, and other metallic substances. Some of these are exceedingly common in connection with industrial processes, while others are rarely met with. Occasionally the pathological aspects of the problem are complicated by chemical considerations, aside from the physical or mechanical properties of the several varieties of metallic dust referred to. In the vast majority of mechanical operations in which metallic dust is generated there is more or less intermixture with particles of mineral dust, which quantitatively may exceed in importance the ascertainable presence of metallic dust. On account of the heavier weight of metallic particles the relative degree of air pollution in factories, workshops, mines, etc., where metallic dust is generated is considerably less than the corresponding amount of air impurities resulting from atmospheric pollution by mineral dust. The injurious consequences of industrial dust exposure are, broadly speaking, proportionate to the amount of dust inhaled into the lungs, but important exceptions to this conclusion are brought out by the consideration in detail of the several kinds of metallic dust, of which, perhaps, lead and arsenic are the most harmful, on account of the additional liability to industrial poisoning. Quantitatively the most important kind of metallic dust as met with under typical industrial conditions is the dust of iron and steel, which, however, is generally more or less intermixed with dust of other metallic or mineral substances. Pure iron and steel dust is rarely met with except under laboratory and other conditions which are not within the plan and scope of the present discussion. Typical employments with metallic dust exposure are file cutters, coppersmiths, engravers, printers, lithographers, nail makers, machinists, gunsmiths, etc. Persons in all of these employments or industries are subject, as a general rule, to an exceptionally high mortality rate from all causes, and a high specific death rate from pulmonary tuberculosis. Some employments in addition are subject to an excessive incidence of nontuberculous respiratory diseases, and particularly is this the case where there is quantitatively a considerable degree of intermixture with silica and similar forms of excessively irritating kinds of mineral dust. The most common form of tuberculosis in occupations with iron and steel dust exposure is medically known as pneumoconiosis, met with in its most typical form in steel grinding and polishing processes, particularly in the manufacture of cutlery and tools and instruments.

RELATION OF VARIATIONS IN OCCUPATIONAL CONDITIONS TO DUST EXPOSURE AND MORTALITY.

The conditions of employment in the 13 industries, trades, and occupations which are considered in detail in the following discussion are so widely at variance with each other that a grouping of the mortality data results in averages which are applicable only with extra caution to particular employments with a more or less ascertainable degree of exposure to metallic dust. Such exposure is nearly always an important predisposing cause of pulmonary tuberculosis and is met with to an exceptional degree of frequency in the grinding and polishing of small metallic objects during the final (finishing) stages of manufacture. On account of the high degree of specialized skill required in many of these occupations, the social loss represented by prolonged illness and premature death from preventable pulmonary tuberculosis is, therefore, of special economic significance.

PROPORTIONATE MORTALITY—UNITED STATES REGISTRATION AREA.

Table 7 is merely intended as a general statement of the essential mortality facts concerning this group of occupations, with special reference to pulmonary tuberculosis, derived from the available official statistics of the Division of Vital Statistics of the United States Census. Subsequently, in addition thereto, tables are included of the more extended experience of a representative industrial insurance company. The practical usefulness of this analysis is naturally rather limited for the reasons stated, but the data provide a fairly trustworthy measure of the relative frequency of pulmonary tuberculosis in the group of occupations under review with a more or less ascertainable degree of health-injurious exposure to metallic dust.

TABLE 7.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG WORKERS EXPOSED TO METALLIC DUST, UNITED STATES REGISTRATION AREA, 1908 AND 1909, BY AGE GROUPS.

Age at death.	Workers exposed to metallic dust.			Per cent of deaths from pulmonary tuberculosis among—	
	Deaths from all causes.	Deaths from pulmonary tuberculosis.		All occupied males.	Farmers, planters, and farm laborers.
		Number.	Per cent of deaths from all causes.		
15 to 24 years	1,230	412	33.5	28.1	23.5
25 to 34 years	2,006	719	35.8	30.9	26.2
35 to 44 years	2,291	656	28.6	24.0	19.1
45 to 54 years	2,166	378	17.5	14.4	12.1
55 to 64 years	1,738	150	8.6	7.6	6.7
65 years and over	1,944	80	4.1	2.6	2.4
Age unknown	10	1	10.0	8.3	7.9
Total, 15 years and over	11,385	2,396	21.0	14.9	8.7

In Table 8 are given data relative to the proportionate mortality from nontuberculous respiratory diseases among workers exposed to metallic dust, 1908 and 1909.

TABLE 8.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES AMONG WORKERS EXPOSED TO METALLIC DUST, UNITED STATES REGISTRATION AREA, 1908 AND 1909.

Cause of death.	Deaths of workers exposed to metallic dust.		Per cent of deaths from all causes among—	
	Number.	Per cent of deaths from all causes.	All occupied males.	Farmers, planters, and farm laborers.
Asthma	23	0.2	0.3	0.3
Bronchitis	92	.8	.9	1.2
Pneumonia	969	8.5	7.8	7.0
Other nontuberculous respiratory diseases	132	1.2	1.1	.9
Total	1,216	10.7	10.0	9.3

The aggregate experience, according to Table 7, for the two years under observation (no subsequent official statistics having been published), indicates a proportionate mortality from pulmonary tuberculosis among those employed in occupations with exposure to metallic dust of 21 per cent. As subsequently shown, this compares with 21.3 per cent for occupations with exposure to mineral dust as ascertained by an analysis of the corresponding data derived from the same official sources. The table indicates an excessive degree of frequency of pulmonary tuberculosis at every divisional period of life, but by reference to the corresponding statistics for occupations with exposure to mineral dust the latter present an even more serious tendency toward an excess in the proportionate mortality; but upon further analysis of the occupations in detail it is shown that exposure to metallic dust is unquestionably on general principles more of a menace to health with particular reference to pulmonary tuberculosis than is exposure to mineral dust. In addition to an excessive mortality from pulmonary tuberculosis the comparative mortality from nontuberculous respiratory diseases, particularly pneumonia, is higher among occupations with exposure to metallic dust than among occupations with exposure to mineral dust.

The details of the proportionate mortality from pulmonary tuberculosis in the principal occupations for which the information is ascertainable from the reports of the Division of Vital Statistics of the United States Census for the two years, 1908 and 1909, are, for purposes of convenience, shown in Table 9.

TABLE 9.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS IN SPECIFIED INDUSTRIES OR OCCUPATIONS WITH EXPOSURE TO METALLIC DUST, UNITED STATES REGISTRATION AREA, 1908 AND 1909, BY AGE GROUPS.

Occupation group.	15 to 24 years.			25 to 34 years.			35 to 44 years.			45 to 54 years.		
	Deaths from all causes.	Deaths from pulmonary tuberculosis.		Deaths from all causes.	Deaths from pulmonary tuberculosis.		Deaths from all causes.	Deaths from pulmonary tuberculosis.		Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Numbor.	Per cent.		Number.	Per cent.		Number.	Per cent.		Number.	Per cent.
Brass workers	25	16	64.0	42	21	50.0	35	11	31.4	48	8	16.7
Engravers	10	5	50.0	23	8	34.8	20	5	25.0	15	1	6.7
Iron and steel workers	460	91	19.8	915	239	26.1	1,084	253	23.3	992	166	16.7
Iron and steel workers (listed as other)	86	22	25.6	149	53	35.6	150	51	34.0	136	27	19.9
Jewelers, gold and silver workers, etc	66	33	50.0	78	31	39.7	94	22	23.4	128	18	14.1
Metal workers, other	52	18	34.6	82	28	34.1	93	21	22.6	77	12	15.6
Printers, lithographers, pressmen	427	186	43.6	551	278	50.5	614	223	36.3	522	112	21.5
Tinplate and tinware workers	104	41	39.4	166	61	36.7	201	70	34.8	248	34	13.7
Total	1,230	412	33.5	2,006	719	35.8	2,291	656	28.6	2,166	378	17.5

Occupation group.	55 to 64 years.			65 years and over.			Age unknown.			Total, 15 years and over.		
Brass workers	26	4	15.4	25	4	16.0	....	......	.....	201	64	31.8
Engravers	19	3	15.8	25	1	4.0	....	......	.....	112	23	20.5
Iron and steel workers	754	64	8.5	826	39	4.7	4	1	25.0	5,035	853	16.9
Iron and steel workers (listed as other)	133	19	14.3	145	7	4.8	1	......	.....	800	179	22.4
Jewelers, gold and silver workers, etc	142	12	8.5	177	6	3.4	1	......	.....	686	122	17.8
Metal workers, other	73	5	6.8	97	1	1.0	1	......	.....	475	85	17.9
Printers, lithographers, pressmen	350	27	7.7	381	14	3.7	2	......	.....	2,847	840	29.5
Tinplate and tinware workers	241	16	6.6	268	8	3.0	1	......	.....	1,229	230	18.7
Total	1,738	150	8.6	1,944	80	4.1	10	1	10.0	11,385	2,396	21.0

Table 10 shows the proportionate mortality from nontuberculous respiratory diseases in occupations with exposure to metallic dust.

TABLE 10.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES IN SPECIFIED INDUSTRIES OR OCCUPATIONS WITH EXPOSURE TO METALLIC DUST, UNITED STATES REGISTRATION AREA, 1908 AND 1909.

Occupation group.	Deaths caused by—									
	Asthma.		Bronchitis.		Pneumonia.		Other respiratory diseases.		All nontuberculous respiratory diseases.	
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
Brass workers			3	1.5	18	9.0	1	0.5	22	10.9
Engravers					3	2.7	1	.9	4	3.6
Iron and steel workers	12	0.2	35	.7	508	10.1	54	1.1	609	12.1
Iron and steel workers (listed as other)	2	.3	11	1.4	54	6.7	11	1.4	78	9.8
Jewelers, gold and silver workers	2	.3	8	1.2	40	5.8	7	1.0	57	8.3
Metal workers, other	2	.4	6	1.3	49	10.3	5	1.1	62	13.1
Printers, lithographers, pressmen	2	.1	14	.5	193	6.8	41	1.4	250	8.8
Tinplate and tinware workers	3	.2	15	1.2	104	8.5	12	1.0	134	10.9
Total	23	.2	92	.8	969	8.5	132	1.2	1,216	10.7

PROPORTIONATE MORTALITY—INDUSTRIAL INSURANCE EXPERIENCE.

The industrial mortality experience of the Prudential Insurance Co. of America is more conclusive, in that the number of specific occupations is more representative of the industries and employments with exposure to metallic dust when considered as a group.[1] The details of the experience are set forth in Tables 11 and 12.

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[1] Additional insurance experience data are contained in Bulletin No. 207 of the Bureau of Labor Statistics of the U. S. Department of Labor, entitled "Causes of Death by Occupation," Occupational Mortality Experience of the Metropolitan Life Insurance Company, Industrial Department, 1911–1913, by Louis I. Dublin, Ph. D., Washington, 1917. This experience, however, with reference to dusty trades with exposure to inorganic dust is practically limited to blacksmiths, coal miners, compositors and printers, iron molders, machinists, masons and bricklayers, painters, paper hangers, and varnishers, and plumbers, gas fitters, and steam fitters. The most recent data are for the year 1914, for the city of New York (Reprint No. 400, U. S. Public Health Service, Washington, 1917), for selected occupations. The proportionate mortality from pulmonary tuberculosis was as follows:

Proportionate mortality (per cent of all causes) from pulmonary tuberculosis, New York City, 1914.

Occupation.	Years of age.					
	15 to 24	25 to 34	35 to 44	45 to 54	55 to 64	65 and over.
Blacksmiths		23.5	33.3	15.1	3.4	3.5
Cigar makers and tobacco workers	40.0	21.0	31.4	31.1	17.6	6.2
Compositors, printers, etc	53.0	66.6	35.7	27.6	19.2	10.3
Machinists	40.5	30.6	34.4	24.6	16.3	1.8
Painters, paperhangers, and varnishers	18.2	45.1	32.2	23.7	21.5	6.1
Teamsters and drivers	35.0	45.2	44.0	28.7	12.1	5.9
All occupations	33.6	33.5	24.8	15.9	7.8	1.9

TABLE 11.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG WORKERS EXPOSED TO METALLIC DUST, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, BY AGE GROUPS.

Age at death.	Workers exposed to metallic dust.			Per cent of deaths due to pulmonary tuberculosis among all occupied males.
	Deaths from all causes.	Deaths from pulmonary tuberculosis.		
		Number.	Per cent of deaths from all causes.	
15 to 24 years	1,912	812	42.5	33.2
25 to 34 years	2,504	1,243	49.6	40.9
35 to 44 years	2,449	966	39.4	32.9
45 to 54 years	1,889	420	22.2	19.0
55 to 64 years	1,541	170	11.0	8.8
65 years and over	1,267	49	3.9	2.9
Age unknown	1	....	....	....
Total, 15 years and over	11,563	3,660	31.7	20.5

TABLE 12.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES AMONG WORKERS EXPOSED TO METALLIC DUST, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914.

Cause of death.	Deaths of workers exposed to metallic dust.		Per cent of deaths from all causes among all occupied males.
	Number.	Per cent of deaths from all causes.	
Asthma	74	0.6	0.6
Bronchitis	116	1.0	1.1
Pneumonia	1,003	8.7	8.8
Other nontuberculous respiratory diseases	182	1.6	1.4
Total	1,375	11.9	11.9

The insurance experience is not strictly comparable with the general mortality for the country at large in that the principle of adverse selection should be considered in view of the fact that only a considerable proportion of the adult risks accepted for industrial insurance are at entry required to submit to a thorough medical examination. A much more important factor, however, is that the occupational analysis in the Prudential experience is more strictly limited to specific occupations with metallic dust exposure, as separate and distinct from industries or groups of closely allied employments which, it is safe to assume, are more representative of the census mortality returns. According to Table 11, the proportionate mortality from pulmonary tuberculosis in occupations with exposure to metallic dust is 31.7 per cent for all ages, which compares with 21 per cent as shown by the census occupation mortality returns. The differences are quite marked and a maximum proportion is reached at ages 25 to 34 when out of 2,504 deaths from all causes among men with exposure to metallic dust, 1,243, or 49.6 per cent, were deaths from pulmonary tuberculosis. The two groups of occupations are not identical and erroneous inferences must be guarded against which might seem justified in view of the apparent discrepancies in the results. Each class of data requires to be considered by itself, for under existing conditions no identical groupings can be made for the occupation mortality of the registration area and the more selected occupation mortality of the industrial insurance company previously referred to. The extremely high proportionate mortality from pulmonary tuberculosis, particularly at the younger ages, among occupations with exposure to metallic dust confirms the earlier conclusion that this form of dust exposure must be considered as the contributory cause of the most serious form of pneumoconiosis, or dust phthisis, as the disease has been called in a strictly scientific discussion of the subject by Collis in the Milroy Lectures, 1915.

The proportionate mortality by specific industries or occupations and by divisional periods of life is shown in Table 13, which will facilitate comparison with the corresponding table for the registration area, but which is subject to the same suggestion of extreme caution as regards the scientific interpretation of the data derived, as explained, from quite different sources.

TABLE 13.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS IN SPECIFIED INDUSTRIES OR OCCUPATIONS WITH EXPOSURE TO METALLIC DUST, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, BY AGE GROUPS.

Occupation group.	15 to 24 years.			25 to 34 years.			35 to 44 years.			45 to 54 years.		
	Deaths from all causes.	Deaths from pulmonary tuberculosis.		Deaths from all causes.	Deaths from pulmonary tuberculosis.		Deaths from all causes.	Deaths from pulmonary tuberculosis.		Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent.		Number.	Per cent.		Number.	Per cent.		Number.	Per cent.
Artificial-flower makers	1	1	100.0	2	1	50.0	....	......	.....	4	1	25.0
Brass workers	91	53	58.2	149	76	51.0	146	64	43.8	99	24	24.2
Compositors and typesetters	795	368	46.3	904	505	55.9	851	350	41.1	567	141	24.9
Cutlery makers	11	3	27.3	11	5	45.5	11	4	36.4	8	1	12.5
Die setters and sinkers.	5	3	60.0	10	2	20.0	5	1	20.0	4	1	25.0
Electrotypers and stereotypers	9	5	55.6	20	9	45.0	19	4	21.1	9	3	33.3
Engravers	71	28	39.4	92	50	54.3	74	35	47.3	63	10	15.9
Gold beaters	7	3	42.9	12	8	66.7	11	4	36.4	8	2	25.0
Grinders	17	7	41.2	56	38	67.9	74	44	59.5	73	35	47.9
Iron and steel workers	403	121	30.0	630	215	34.1	648	214	31.3	606	89	14.7
Jewelers	110	56	50.9	144	84	58.3	106	48	45.3	132	28	21.2
Polishers	136	59	43.4	230	129	56.1	241	106	44.0	173	43	24.9
Pressmen	168	72	42.9	151	72	47.7	116	51	44.0	45	9	20.0
Tool and instrument makers	88	33	37.5	93	49	52.7	111	41	36.9	98	33	33.7
Total	1,912	812	42.5	2,504	1,243	49.6	2,449	966	39.4	1,889	420	22.2

TABLE 13.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS IN SPECIFIED INDUSTRIES OR OCCUPATIONS, ETC.—Concluded.

Occupational group.	55 to 64 years.			65 years and over.			Age unknown.			Total, 15 years and over.		
	Deaths from all causes.	Deaths from pulmonary tuberculosis.		Deaths from all causes.	Deaths from pulmonary tuberculosis.		Deaths from all causes.	Deaths from pulmonary tuberculosis.		Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent.		Number.	Per cent.		Number.	Per cent.		Number.	Per cent.
Artificial-flower makers	4	1	25.0	2	......	......	......	......	......	13	4	30.8
Brass workers	93	15	16.1	55	......	......	......	......	......	633	232	36.7
Compositors and typesetters	427	42	9.8	318	14	4.4	1	......	......	3,863	1,420	36.8
Cutlery makers	8	3	37.5	6	1	16.7	......	......	......	55	17	30.9
Die setters and sinkers	3	1	33.3	1	......	......	......	......	......	28	8	28.6
Electrotypers and stereotypers	6	1	16.7	2	......	......	......	......	......	65	22	33.8
Engravers	41	3	7.3	43	1	2.3	......	......	......	384	127	33.1
Gold beaters	4	......	......	11	......	......	......	......	......	53	17	32.1
Grinders	55	14	25.5	30	5	16.7	......	......	......	305	143	46.9
Iron and steel workers	550	48	8.7	459	13	2.8	......	......	......	3,332	700	21.0
Jewelers	144	16	11.1	176	6	3.4	......	......	......	812	238	29.3
Polishers	112	16	14.3	72	2	2.8	......	......	......	964	355	36.8
Pressmen	27	3	11.1	16	......	......	......	......	......	523	207	39.6
Tool and instrument makers	67	7	10.4	76	7	9.2	......	......	......	533	170	31.9
Total	1,541	170	11.0	1,267	49	3.9	1	......	......	11,563	3,360	31.7

On account of the importance of nontuberculous respiratory diseases Table 14 is also included, showing the proportionate mortality from asthma, bronchitis, pneumonia, and other respiratory diseases among workers in occupations with exposure to metallic dust, but without reference to divisional periods of life.

TABLE 14.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES IN SPECIFIED INDUSTRIES OR OCCUPATIONS WITH EXPOSURE TO METALLIC DUST, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914.

Occupation group.	Deaths caused by nontuberculous respiratory diseases.									
	Asthma.		Bronchitis.		Pneumonia.		Other.		Total.	
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
Artificial-flower makers	......	......	1	7.7	1	7.7	......	......	2	15.4
Brass workers	4	0.6	1	.2	51	8.1	19	3.0	75	11.8
Compositors and typesetters	19	.5	35	.9	343	8.9	55	1.4	452	11.7
Cutlery makers	......	......	......	......	4	7.3	1	1.8	5	9.1
Die setters and sinkers	......	......	1	3.6	4	14.3	......	......	5	17.9
Electrotypers and stereotypers	......	......	1	1.5	4	6.2	......	......	5	7.7
Engravers	2	.5	2	.5	34	8.9	5	1.3	43	11.2
Gold beaters	......	......	......	......	5	9.4	2	3.8	7	13.2
Grinders	3	1.0	6	2.0	28	9.2	9	3.0	46	15.1
Iron and steel workers	27	.8	46	1.4	307	9.2	50	1.5	430	12.9
Jewelers	5	.6	10	1.2	61	7.5	7	.9	83	10.2
Polishers	5	.5	5	.5	77	8.0	17	1.8	104	10.8
Pressmen	2	.4	3	.6	45	8.6	9	1.7	59	11.3
Tool and instrument makers	7	1.3	5	.9	39	7.3	8	1.5	59	11.1
Total	74	.6	116	1.0	1,003	8.7	182	1.6	1,375	11.9

It does not seem necessary to enlarge further upon the facts disclosed by the preceding comparative statistics which emphasize with a sufficient degree of scientific conclusiveness the obvious health-injurious consequences of considerable and continuous exposure to the inhalation of metallic dust. It is clearly recognized that the statistical data utilized for the present purpose are of limited intrinsic value, but they are in the main quite fully confirmed by the more extended special consideration of occupations or industries, where the exposure to metallic dust is sufficient to warrant inclusion within the plan and scope of the present discussion.

ENGLISH MORTALITY STATISTICS.

In conclusion, however, it has seemed advisable to add to the preceding observations Table 15, obtained from English official sources and showing the combined mortality of tool and instrument makers, brass workers, and printers and compositors. This table may safely be considered sufficiently representative of the entire group of occupations with exposure to metallic dust in the absence of more extensive information, which, unfortunately, is not available.

TABLE 15.—MORTALITY FROM ALL CAUSES, FROM PULMONARY TUBERCULOSIS, AND FROM OTHER DISEASES OF THE RESPIRATORY SYSTEM, IN OCCUPATIONS EXPOSED TO METALLIC DUST, COMPARED WITH THAT OF ALL OCCUPIED MALES, IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[Source: Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 due to all causes among—		Death rate per 1,000 due to pulmonary tuberculosis among—		Death rate per 1,000 due to other diseases of the respiratory system.	
	All occupied males.	Occupations exposed to metallic dust.	All occupied males.	Occupations exposed to metallic dust.	All occupied males.	Occupations exposed to metallic dust.
15 to 19 years......	2.44	2.73	0.54	0.73	0.24	0.30
20 to 24 years......	4.41	5.28	1.55	2.73	.48	.45
25 to 34 years......	6.01	6.29	2.03	3.33	.77	.69
35 to 44 years......	10.22	11.68	2.74	5.05	1.66	1.62
45 to 54 years......	17.73	20.97	3.04	5.22	3.32	3.55
55 to 64 years......	31.01	36.03	2.16	3.91	6.54	7.94
65 years and over..	88.39	92.52	1.11	1.54	17.77	22.46

GENERAL CONCLUSIONS.

According to this table the general death rate from all causes and the specific death rate from pulmonary tuberculosis among men in occupations with exposure to metallic dust is decidedly excessive at all ages, and extremely high during the age period 25 to 54, which, for economic reasons, is obviously of special social and medical importance. The mortality from nontuberculous respiratory diseases in the English experience was slightly below the average for occupations with exposure to metallic dust, a condition which is not confirmed by the data derived from American sources. It should be considered in this connection that many important specific employments with exposure to metallic dust show a mortality from pneumonia, asthma, and bronchitis distinctly above the average. The relative frequency of these two groups of diseases among persons employed in occupations with exposure to metallic dust occasionally involves serious difficulties in medical diagnosis and death certification, and the conclusion of Sir Thomas Oliver, with reference to miners applies to metal workers, though possibly to a lesser degree, that "it is difficult to say where and how miners with pneumoconiosis become tuberculous, but there is nothing to suggest that they become infected differently to other people." This, of course, applies to the precise process of infection rather than to the increased liability resulting from a preexisting mechanical injury to the lungs in consequence of considerable and continuous inhalation of metallic and mineral dust. As further said by Sir Thomas Oliver in this connection, "The infection must take place either in the mine, in the home, in the public house, or in some place of amusement." It may safely be asserted, however, that "in the absence of sanitary control of work places and a general conformity to sanitary rules, especially with reference to indiscriminate expectoration, the liability to tuberculous infection must be increased on account of the occupation in the case of persons employed in occupations with more than normal exposure to irritating dusts, whether of organic or inorganic origin, or both." This conclusion applies as much to occupations with exposure to metallic dust as to those with exposure to mineral dust, but of the two, under given conditions, persons engaged in the former are in all probability more liable to pulmonary tuberculosis than those engaged in the latter and less liable to nontuberculous respiratory diseases, particularly asthma and bronchitis.

THE IRON AND STEEL INDUSTRY.

VARIATIONS IN OCCUPATIONAL DUST EXPOSURE.

The iron and steel industry is inclusive of such a large number of more or less specialized and widely varying employments that any and all general mortality data relating thereto can not be considered conclusive concerning any one particular group of occupations. The conditions of employment in the iron and steel industry in the United States, with detailed descriptive accounts of particular occupations, were reported upon by the United States Bureau of Labor Statistics in response to a Senate resolution, in 1911. The large number of individual employments therein described proves conclusively the practical limitations of general data concerning the mortality and morbidity of iron and steel workers considered as a group. Most of these have, therefore, for the present purpose, been discussed separately in the 14 groups of occupations with exposure to metallic and mineral dusts. Out of 172,706 enumerated employees in the iron and steel industry, according to the report of the United States Bureau of Labor Statistics on Conditions of Employment in the Iron and Steel Industry, 61.9 per cent were employed in producing departments and 38.1 per cent in connection with power, mechanical operations, or the yard force. As to the branches of the industry in the producing departments, 18.2 per cent of the employees were at work on blast furnaces; 3.3 per cent at Bessemer converters; 8.5 per cent at open-hearth furnaces; 3.9 per cent at puddling mills; 0.4 per cent at crucible furnaces; 3.3 per cent at blooming mills; 3.4 per cent at plate mills; 2.6 per cent at standard rail mills; 2 per cent at structural, light rail, and other shapes mills; 1.9 per cent at miscellaneous mechanical mills; 10 per cent at bar mills; 1.4 per cent at garrett rod mills; 0.5 per cent at miscellaneous rod mills; and 2.5 per cent at tube mills. It is, therefore, shown that numerically the men employed in direct connection with producing operations at blast furnaces, Bessemer converters, open-hearth furnaces, puddling mills, and crucible furnaces constitute 34.3 per cent of the total labor force. The dust exposure in even these closely related employments varies quite considerably, aside from important variations in exposure to heat, temperature changes, etc. The remainder of the group of iron and steel workers, 27.6 per cent, were employed in iron and steel mills, including a large number of highly specialized occupations, with possibly even greater variations in exposure to dust, heat, temperature changes, etc. Conclusions applicable to the health or mortality of one group of employees, for illustration, connected with work at blast furnaces, would probably not apply to another group of employees at work in the plate mills. It is, however, quite impracticable to give individual consideration to the hygiene of all the numerous employments in the iron and steel industry, since most of the available mortality and morbidity data have reference only to the industry as a whole. The experience of several important and long-established benefit funds, if subjected to critical analysis, would undoubtedly throw much light upon important sanitary and medical conclusions concerning the health conditions in the steel industry; but thus far only a general analysis of the experience has been attempted.

OCCURRENCE OF INJURIOUS DUST AMONG STEEL WORKERS.

The most qualified scientific investigation of the occurrence and mitigation of injurious dust among steel workers is by Dr. J. A. Watkins, of the United States Public Health Service in cooperation with the Bureau of Mines (Technical Paper 153, Washington, 1917). The report includes a brief discussion of the pathogenicity of industrial dusts, differentiating the three chief ways in which dust may act injuriously according to the character of the dust particles, (1) by irritant action, (2) by toxic action, and (3) by mechanical action. The conclusion is advanced that much of the dust inhaled never reaches the lungs because of its being retained in the nose, throat and mouth. Some of these dusts, it is pointed out, interfere with the proper physiological action of the stomach and intestines, while others have serious effects on the skin, acting as local irritants. The principal places where dust is found in steel works are storage bins, blast furnaces, gas stoves, gas washers and blowers, dolomite sheds, open-hearth furnaces, rolling mills, soaking pits, gas producers, Bessemer converters, foundries, and in connection with the grinding equipment. The observations in detail are entirely too brief for practically useful conclusions. In order to determine the extent to which the various dusts are found to be suspended in the atmosphere of the work places examined, an apparatus was used devised by Lanza and Higgins and described in Technical Paper 105, Bureau of Mines, Washington, 1915. The descriptive accounts of the dusts collected are exceptionally valuable. The description of iron ore dust is given in full as follows:

> The table shows that at times iron-ore dust is suspended in the atmosphere around the ore bins in exceptionally large quantities—as much as 23.5 mmg. per 100 liters. While this dust contains many particles varying from 4 to 10 microns in size, a characteristic feature noted in the study of this dust was the enormous number of ultramicroscopic particles. The larger particles readily break up into these ultramicroscopic particles in a fluid medium. A somewhat similar occurrence probably takes place in the respiratory tract; and if so would make the removal of these particles by coughing or expectorating very difficult, if not impossible. The larger particles are irregular, roughly spherical, and have few sharp edges but some points. Iron-ore dust has no toxic action and the particles examined were not very hard. Its physiological effect on man can be surmised only, but is probably limited to that caused by the mechanical action of the particles, which act as irritating bodies where they lodge in the respiratory tract.

Additional descriptions are of coke dust, limestone dust, flue dust, graphite dust, dolomite dust, and other refractory material and roll scale. With reference to dolomite dust, it is said that—

> As regards industrial hygiene, dolomite, $CaMgCO_3$, is the most important dust in a steel plant, not only because of its character and action but also because of the enormous quantities of it suspended in the atmosphere of certain working locations. The dolomite particles examined are very irregular, with few sharp points, but generally with some sharp edges, and are hard. The particles examined

were 5 to 15 microns in size. Calcined dolomite contains a large percentage of free lime which on becoming moist slakes and is then very irritating to the tissues of the body, particularly those of the nose, throat, and eyes. Its effect on the delicate membranous lining of the respiratory tract can be readily surmised.

Of special interest is the descriptive statement of ganister dust, in which it is referred to as a highly siliceous sandstone, used to some extent in patching and repairing the interior of an open-hearth furnace. The silica particles examined were 5 to 20 microns in size, irregular, angular, sharp, and exceedingly hard.

The general methods of mitigating the dust menace in steel works are (1) preventing dust suspension, (2) removing suspended dust from air, and (3) providing against the inhalation of dust. A fourth method is "to house in completely the department in which there is much suspended matter and prohibit employees from working or remaining therein." The suggestions, to be entirely conclusive and practically useful, require to be further amplified by illustrations of existing methods which are known not to have been a matter of material interference with at least a moderate degree of working efficiency. It is, of course, a mere commonplace that "foremost among the methods employed for dust removal is that of an efficient system of exhausting and supplying air. A system of electric precipitation can be used, but its usefulness is limited largely to dust in flues." Both of these are extremely difficult of installation in many plants constructed in conformity with the factory methods of the past.

The observations in the report on the abatement of dust at the ore bins, the blast furnaces, and the dolomite shed are of considerable value. With reference to the dust problem in foundries it is said, in conclusion, that—

> Many and diverse conditions give rise to dust in the foundry. To abate the dust a great deal of effort and every means of prevention and mitigation must be employed. Castings should be cleaned and "blasted" in a separate room where only those men needed for the work are allowed to remain. These employees should be required to wear respirators. Casting, especially the casting of brass and similar alloys, should be done in a separate building where precautions are taken to insure ample ventilation by natural and artificial means. The main foundry room should be given more floor space and, except where molds are made, should have suitable flooring of steel plate or brick. This flooring should be sprinkled with water frequently. In addition provision should be made for an abundant supply of fresh air. Grinding wheels should be supplied with an effective exhaust system, and as an additional safeguard the men engaged should be required to wear respirators.

The report is a promising indication of more qualified scientific inquiries into a field of industrial hygiene which has heretofore been practically neglected almost in its entirety.

DUST EXPOSURE AT BLAST FURNACES.

In the report of the Bureau of Labor Statistics each important branch of the industry is separately described and much useful information is contained therein regarding occupational exposure in at least the more important employments. At the blast furnaces, for illustration, the so-called larry men are exposed to the dust of limestone, coke, and other materials, including, of course, a more or less important proportion of metallic dust. So-called bottom fillers are considerably exposed to dust in connection with the shoveling of materials into barrows, while top fillers and stove cleaners are still more exposed to dust and heat, in addition to the serious risk of overexertion, on account of the heavy physical labor required, and frequently, also, to trying weather conditions. The stove cleaners, it is explained in the report referred to, "remove the cinder, dust, and various débris that accumulate in the stoves," which obviously must involve an exceptional amount of metallic and mineral dust exposure. The so-called "dustmen," which term includes slag-dust laborers, dust wheelers, and dust-catcher men, "remove the dust which accumulates in the gas flues and in the dust catcher," and the work is particularly referred to as being "disagreeable on account of the hot dust, and likely to be dangerous if the dust is not thoroughly wetted down while being removed," which, it may be said, is not often the case. At the blast furnaces the so-called clay men "prepare and deliver the clay for the stopping of the tap hole," but the exposure here is to mineral rather than to metallic dust. Iron breakers, however, who break up the iron molds or "pigs," are in all probability subject to considerable inhalation of mineral dust mixed with minute iron particles, but in modern plants where pig-casting machines are used this risk is eliminated. These brief references to a single important branch of the steel industry illustrate the widely varying conditions of dust exposure and suggest the practical importance of much more specialized investigations than have heretofore been made into the health-injurious effects of particular occupations or groups of employment. At the blast furnaces alone 35 particular occupations are differentiated or briefly described in the report of the Bureau of Labor Statistics previously referred to.

DUST EXPOSURE AT BESSEMER CONVERTERS.

At the Bessemer converters there are at least 29 specialized occupations, of which apparently those with most serious dust exposure are the cupola hoist men, the cupola chargers, the cupola liners, the vessel scrapers, the vessel men and vessel men's helpers, and, most of all, the bottom makers and helpers, who repair and rebuild converter bottoms. The last-named operation is of special interest and hygienic importance and is briefly described in the report of the Bureau of Labor Statistics, as follows:

> The bottom consists essentially of (1) a cylindrical steel casing sloping out at the top to the diameter of the vessel, the lower part of which forms the "blast box" into which the blast is admitted by a large pipe. This casing is provided with keys or with other appliances by which it can be quickly and securely fastened to the body of the converter. (2) Above the "blast box" is the refractory bottom, which is pierced by a large number of small holes for admitting and distributing the blast in the vessel. In acid vessels these "tuyeres" or holes are formed in fire-clay bricks of special design (in practice the entire brick is known as a "tuyere") around which ganister is rammed. When the bottom is removed by the vessel men, the bottom makers and helpers cool it with water and then chip out all the ganister and knock out the "tuyere bricks." New tuyere bricks are then placed in position, and crushed moist ganister is tightly rammed around them until it is level with their top. The entire bottom is then placed in an oven where it is kept at a steady heat until thoroughly dried. In addition to this work the bottom makers' helpers in many plants also grind the refractory materials used for this purpose and also for repairing vessels and ladles.

The ganister which is used in connection with this operation gives rise to a dust of a very high degree of injuriousness, but the degree of such exposure is much less in bottom making than in the manufacture of the dust itself. Ganister mining and crushing has been described in Oliver's Dangerous Trades, in part, as follows:

> Workers engaged in crushing basic slag, in the breaking of certain rocks, in the manufacture of millstones, in stonemason's work, and kindred occupations, are peculiarly liable to chronic inflammation of the air tubes, caused by the inhalation of dust of an irritant kind. This, it is believed, leads to lung fibrosis. Where the operatives form part of a large community in which individuals are employed in many and varied trades, it is conceivable that fibrosis of the lungs may be mistaken for tubercular pulmonary consumption, and it may not be realized that the cause is due to the occupation of the sufferer.
>
> Ganister is a hard, close-grained, silicious stone which often forms the stratum that underlies the coal seam. A footnote in Dr. Percy's Fuel says: "Dinas rock is believed to be a millstone grit of the carboniferous system, and the geological equivalent of the bed termed 'ganister' at Sheffield." It is found in Yorkshire, Durham, North and South Wales, and elsewhere. When crushed and ground into dust it is used as a fire-resistant, chiefly for lining Bessemer and other steel converters, for the manufacture of bricks likely to be subjected to great and continuous heat, and it is sometimes mixed with, or substituted for, Stannington or other clays, which, together with ground cinders and old ground pot, are used for the manufacture of crucibles in which certain kinds of steel are made.

The exposure here, of course, is to mineral rather than metallic dust, but in the United States, at least, employments in connection with ganister are chiefly in the iron and steel industry, and especially in the repairing and rebuilding of converter bottoms. For a thoroughly well considered discussion of the subject the extended account in Oliver's Dangerous Trades, by Hamilton P. Smith, should be consulted.[1]

Other important occupations in connection with Bessemer converters where the dust exposure appears to be exceptional are ladle liners, ingot strippers, and cinder men, the latter cleaning up and removing the cinder and metal from the pit or floor of the Bessemer building, and taking care of the slag on the cinder dump. As explained in the report of the Bureau of Labor Statistics, this work, for the most part, "is done under conditions of great heat, and, when working around and under the vessels and ladles, of great danger of being severely burned or of receiving minor injuries."

DUST EXPOSURE AT OPEN-HEARTH FURNACES.

Twenty occupations of the open-hearth furnaces are described in detail in the report of the Bureau of Labor Statistics, and of these occupations the following involve the most serious risk of dust exposure: Stokers, who unload the materials and sort and assemble the different grades of scrap iron in piles, etc.; charging-machine operators, who generally work on more or less dust-covered floors and in front of furnaces while discharging materials under, frequently, rather trying conditions; pitmen, who prepare the pit for casting, set the molds, build the runners, etc.; and general laborers, including ash men, ash wheelers, cinder dump men, clean-ups, grinding laborers, mixing laborers, mixing-house laborers, etc. In most of these occupations the dust exposure is quite considerable, but naturally the major portion of the dust is of a mineral nature. The highest degree of health-injurious exposure is probably in connection with the relining of the furnaces where frequently all reasonable and necessary safeguards, such as the previous spraying of the materials, etc., are neglected. Most of the work, however, is done by casual labor, so that only in rare cases are occupations of this character followed for a long period of years.

DUST EXPOSURE AT PUDDLING MILLS.

In puddling mills the number of special occupations is not fewer than 23 and most of these involve more or less dust and heat exposure, frequently, however, quite difficult of precise ascertainment.

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[1] See also Sir Thomas Oliver's observations on slag crushing, in Allbutt and Rolleston's A System of Medicine, vol. 5, p. 457; and his remarks on ganister crushing and mining, in the same volume, p. 456; and additional observations in his Diseases of Occupation, p. 298 et seq. Sir Thomas Oliver's most recent conclusions are set forth briefly in Kober and Hanson's Occupational Diseases and Vocational Hygiene, New York, 1916, p. 222.

Puddling is a highly skilled occupation and, according to the report of the Bureau of Labor Statistics, "requires considerable experience, and the puddler's work is perhaps the hardest physical labor in the industry, and, moreover, the largest part of it is done under conditions of extreme heat." Wherever work is done under conditions of extreme heat the dust exposure is increased on account of the extreme dryness of practically all the materials used, directly or indirectly, in productive operations. Puddlers' helpers assist in the lining of the furnaces and in the charging and drawing of the metal, which naturally involves exposure to mixed mineral and metallic dust. Cinder men tap the slag from the furnace, quite frequently under rather primitive conditions, involving considerable dust exposure. Many of the other occupations resemble those previously referred to. The crucible process in steel manufacture is now of relatively small importance, but of exceptional interest from sanitary and medical points of view. Conditions vary widely in different plants, according to whether the furnaces are heated by gas, coal, or coke, and whether modern processes or the antiquated methods of an earlier period are employed. The principal occupations are melters, pullers out, and molders. The latter prepare and set the small ingot molds into which the steel is cast, and they strip the same when the cast is completed. All this involves considerable dust exposure and the liability to sudden temperature changes. Frequently these men while at work near the furnaces are not properly protected against cold drafts and other trying weather conditions. Among the unclassified employments chiefly carried on by unskilled labor are mixers, pot shakers, pot boys, pipe makers, compounders, and ladle men, all more or less exposed to considerable mixed metallic and mineral dust.

OBSERVATIONS ON THE PHYSIQUE OF IRON AND STEEL WORKERS.

The foregoing are the principal converting branches of the modern iron and steel industry, preliminary to manufacturing processes proper. The special occupations in these are also extremely varied but in most respects they resemble, as regards at least the most dangerous employments, those previously referred to. Working generally in rolling, rod, and tube mills involves, naturally, a continuous and probably considerable exposure to the inhalation of metallic dust, aside from other more or less health-injurious conditions, such as sudden temperature changes, extreme heat, etc. As a natural process of occupational selection, most of the men employed in the iron and steel industry are physically of a superior class, and, therefore, more resistant to disease than ordinary laborers or men employed chiefly in indoor occupations. There is the additional advantage that in most of these employments the wages are above the general average, while, except in the continuous processes, the hours of labor are rarely excessive. Regarding any and all of these employments, there is at present only fragmentary information as to the health-injurious effects of the different employments, but considered in the aggregate the available data are fairly conclusive that the mortality and morbidity are not above the average. This conclusion, however, must not be carried too far, for it can not be made to apply to the numerous and thoroughly specialized occupations which are carried on under frequently very trying conditions of extreme heat, sudden temperature changes, and exposure to metallic and mineral dust.

HEALTH-INJURIOUS CONDITIONS AT IRON AND STEEL WORKS.

W. Gilman Thompson. in his treatise on "The Occupational Diseases" (pp. 191–196), refers at some length to the iron and steel industry, chiefly to foundry men and rolling-mill men, and he includes among the health-injurious circumstances exposure to toxic gases, glare of excessive light, and irritation of the lungs from steel dust, causing pneumoconiosis. He also suggests an exceptional liability to chronic nephritis and arteriosclerosis. He quotes Röpke to the effect that in German steel mills 20 to 22 per cent of the illnesses among the workmen concern the respiratory organs. He observes that—

> Iron is in no sense a chemical irritant to the body, being a natural ingredient of the hemoglobin. Iron and steel dust, however, by virtue of the hardness and sharpness of the particles, are irritant to the bronchial mucosa when inhaled, and foster the development of fibroid phthisis and subsequent acquisition of pulmonary tuberculosis. The smelting of iron and steel and various hardening processes are capable of being injurious in several ways. Thus the workmen are exposed to great heat and perspiration which is often suddenly checked, especially in winter. The excessive heat and light to which puddlers and founders are exposed when the glare from furnace doors reaches them may injure the eyes permanently, and they may acquire superficial or more serious burns. Particles of iron or steel may be driven into the skin of the face and exposed upper half of the body, marking it like tattoo. The workmen, as a result of frequent extreme changes in temperature, are prone to lumbago or myalgia and chronic rheumatism, and, from heavy lifting, frequently have sprains and muscle strain. In galvanizing sheet iron hydrochloric acid is used, the fumes of which are injurious. Various processes of steel hardening are liable to prove harmful through the action of other substances, such as the cyanides, ferrosilicon, etc. Cutlery and other articles of steel manufacture are dipped into baths of molten lead or boiling oil, the fumes from which may prove highly injurious. In the hot rooms in which smelting and hardening processes are conducted the workmen are subject to acute and chronic nasal catarrh, and Sager and Weickert have found otitis media as a further not

uncommon result. Röpke (Berufskrankheiten des Ohres) has described perichondritis of the external ear caused by the packing of hard metallic dust in the auditory meatus. He also found labyrinthine inflammation in some cases.

The metallurgy of iron is of course quite closely related to metallurgical processes generally as carried on in continuation of mining industries. Smelting processes are elsewhere considered, though briefly, since thus far no extensive and conclusive investigations have been made concerning the differential occupational health hazards in the several important branches of the smelting industry with a due regard to the nature of the metallic substances produced. Conclusions applicable to copper smelters are, for illustration, quite inapplicable to quicksilver reduction works, and the same observation applies to gold and lead smelting, separately considered. As observed by Thompson—

> In smelting works the laborers are much exposed to the inhalation of toxic gases from the ovens, especially carbon monoxide derived from coke or otherwise. In such cases headache, vertigo, and tinnitus are complained of, and anemia and nervousness ensue. Kayser (Wiener med. Woch. 1893, No. 41) reported a case of such poisoning in which the victim remained 36 hours in coma, and on recovery presented symptoms of labyrinthine disease. Such extreme cases are very rare. Rohrer (Haugs'klin. Vortr., Bd. 1, Heft 3) reported 5 cases among furnace stokers who were subjected to the inhalation of water gas, with the result of chronic carbon monoxide poisoning. They suffered from headache, nausea, and disturbances of hearing which were both nervous and due to otitis. Erosions of the nasal septum and atrophic rhinitis were also observed occasionally.

THE HYGIENIC MENACE OF STEEL DUSTS.

To a limited extent this observation applies also to the iron and steel industry, chiefly, of course, to work in connection with initial conversion processes. In the continuation of these processes and toward the final finishing of the product, it is quite apparent, as pointed out by Thompson, that the danger to the lungs in the cleaning of iron and steel castings is most serious, and that in open-hearth processes and in the breaking up of iron molds and castings particles of coal or charcoal and iron rust are inhaled and the workmen sweat heavily. They are, therefore, peculiarly exposed to nasal, bronchial, and middle-ear catarrh, and he remarks, in this connection, that—

> The sharp particles of dust accumulate in crusts with the nasal mucus and cause ulceration and epistaxis. There may be atrophic rhinitis with loss of sense of smell and uncomfortable dryness of the nose. The atrophy may involve the mucosa of the nasopharynx, which becomes reduced in sensibility so that mucus accumulates with-

out exciting expulsive effort. This lack of sensation may favor the further entrance into the bronchi and lungs of irritant material. Graphite and coal dust were found by Merkel embedded in the lungs in four autopsies upon men who had been employed as iron molders. Particles of steel and iron dust which reach the pulmonary alveoli choke them up and become embedded in their walls, where they excite perialveolar irritation with inflammatory products, chiefly fibrous.

MORTALITY OF GRINDERS AND POLISHERS.

These observations bear directly upon the extremely important practical question of differentiating fibroid phthisis from ordinary pulmonary tuberculosis as modified by conditions of employment in the metal trades. The more delicate methods of manufacture with exposure to iron and steel dust have been briefly described under grinders, polishers, and tool and instrument makers, as well as less important allied occupations. A statement, however, by W. Gilman Thompson, based on experience had at Sheffield, England, during the eight years ending with 1909, among steel grinders and polishers in the hardware industries may be here referred to, it being stated that the death rate was 30.4 per 1,000, of which, however, one-half was attributable to tuberculosis and more than one-sixth to other pulmonary diseases. Thompson properly emphasizes the fact that this class of workmen is representative of a selected group as to age and original physical strength, so that the excessive mortality is on that account decidedly more significant. Thompson also refers to the mortality of Solingen, which is the center of the German cutlery industry, where during 1910 the general mortality from tuberculosis was 1.8 per 1,000, while in the cutlery and tool industry it was 9.3, and he quotes in this connection from a report of the State Board of Health of Massachusetts for the year 1907, with special reference to the tool industry at Northampton, Mass., that the grinders and polishers employed in these industries showed a mortality from pulmonary diseases, including tuberculosis, of nearly 73 per cent of the mortality from all causes. He also makes mention of a rather rare case of pulmonary emphysema reported to the New York State Bureau of Labor which resulted from manufacturing steel wool. He remarks in conclusion that—

> In foundries, rolling mills, steel-plate works, and the like, the lifting of heavy weights tends in time to strain the circulation and give rise to cardiac hypertrophy. Excessive sweating in these occupations leads to lessening of the fluidity of the blood and induces excessive thirst, which the workmen often assuage with quantities of beer and other alcoholic drinks. The combination of vascular strain and alcoholism leads to early arteriosclerosis, which in turn results in hypertrophy of the heart. When large quantities of cold fluids are drunk acute gastrointestinal catarrh is very liable to ensue.

DUST EXPOSURE IN THE CHIPPING OF IRON AND STEEL CASTINGS.

Among the minor but important health-injurious processes in the iron and steel industry a brief reference should be made to iron and steel "chipping." This employment has been briefly described by Hayhurst, as follows:

> Chipping of iron and steel castings is another exceedingly dusty and also dangerous procedure from the flying particles which are created by the use of both hand or pneumatic tools.

The reference is particularly to the danger of eye injuries, but the metallic-dust hazard in this employment is of even greater importance. Hayhurst suggests that outside of the use of respirators and individual goggles it is advisable to protect the ears by cotton, for where pneumatic tools are used the deafening noise is productive of shocks to the nervous system. Previous to the chipping castings are usually subjected to the so-called process of tumbling, which consists in the placing of a number of castings, as described by Hayhurst, "in a revolving cylinder, called a 'rattler,' in order to shake off the mold dust and to smooth down certain imperfections." He explains that the cylinder which contains the material should be entirely inclosed, since an immense amount of dust is created, but where this is not practicable an efficient air exhaust or blast system may be used for the control of the dust hazard. In employments of this character most of the labor, however, is of a casual nature and it is extremely rare to meet with men who have been exposed to the same occupational hazard for a long period of time.[1]

MORTALITY OF IRON AND STEEL WORKERS—UNITED STATES REGISTRATION AREA.

The mortality of iron and steel workers has been reported upon for the years 1908 and 1909 by the Division of Vital Statistics of the United States Census Bureau, but no subsequent information has been made public and the data are, therefore, limited to the years referred to. According to the census report, out of 5,035 deaths from all causes, 853, or 16.9 per cent, were from pulmonary tuberculosis. The details of the mortality of iron and steel workers, by divisional periods of life, are shown in Table 16, compared with the mortality of all occupied males, and of farmers, planters, and farm laborers.

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[1] Considerable progress has been made in the direction of perfecting methods of eye protection, as illustrated by exhibits at the National Exposition of Safety and Sanitation, New York City, under the auspices of the National Safety Council and the American Museum of Safety, Grand Central Palace, New York City, 1917. A permanent exhibit of safety goggles or other methods of eye protection is maintained at the American Museum of Safety, 18 West Twenty-fourth Street, New York City.

TABLE 16.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS OF IRON AND STEEL WORKERS, OF ALL OCCUPIED MALES, AND OF FARMERS, PLANTERS, AND FARM LABORERS, UNITED STATES REGISTRATION AREA, 1908 AND 1909, BY AGE GROUPS.

Age at death.	Iron and steel workers.			All occupied males.			Farmers, planters, and farm laborers.		
	Deaths from all causes.	Deaths from pulmonary tuberculosis.		Deaths from all causes.	Deaths from pulmonary tuberculosis.		Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent of deaths from all causes.		Number.	Per cent of deaths from all causes.		Number.	Per cent of deaths from all causes.
15 to 24 years	460	91	19.8	34,985	9,837	28.1	6,130	1,441	23.5
25 to 34 years	915	239	26.1	56,001	17,326	30.9	6,665	1,748	26.2
35 to 44 years	1,084	253	23.3	63,093	15,128	24.0	7,227	1,377	19.1
45 to 54 years	992	166	16.7	68,903	9,910	14.4	10,224	1,234	12.1
55 to 64 years	754	64	8.5	69,254	5,231	7.6	14,836	999	6.7
65 years and over	826	39	4.7	113,469	2,992	2.6	45,510	1,105	2.4
Age unknown	4	1	25.0	618	51	8.3	203	16	7.9
Total, 15 years and over.	5,035	853	16.9	406,323	60,475	14.9	90,795	7,920	8.7

TABLE 17.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES OF IRON AND STEEL WORKERS, OF ALL OCCUPIED MALES, AND OF FARMERS, PLANTERS, AND FARM LABORERS, UNITED STATES REGISTRATION AREA, 1908 AND 1909.

Cause of death.	Deaths of iron and steel workers.		Deaths of all occupied males.		Deaths of farmers, planters, and farm laborers.	
	Number.	Per cent of deaths from all causes.	Number.	Per cent of deaths from all causes.	Number.	Per cent of deaths from all causes.
Asthma	12	0.2	1,031	0.3	262	0.3
Bronchitis	35	.7	3,522	.9	1,049	1.2
Pneumonia	508	10.1	31,889	7.8	6,333	7.0
Other nontuberculous respiratory diseases.	54	1.1	4,280	1.1	824	.9
Total	609	12.1	40,722	10.0	8,468	9.3

Table 16 is suggestive of a rather high but not particularly excessive mortality from pulmonary tuberculosis; but Table 17 shows that in addition thereto there is a mortality from nontuberculous respiratory diseases of 12.1 per cent for iron and steel workers. Of this group of diseases asthma causes a proportionate mortality of 0.2 per cent; bronchitis, 0.7 per cent; pneumonia, 10.1 per cent; and other respiratory diseases, 1.1 per cent. Combining pulmonary tuberculosis and nontuberculous respiratory diseases, the proportionate mortality from all lung diseases is 29 per cent, which must be considered relatively high, since the group of iron and steel workers includes those in many occupations not exposed to particularly health-injurious conditions. The table confirms the results of other investigations into the mortality of iron and steel workers of the United States and other countries.

MORTALITY OF IRON AND STEEL WORKERS—INDUSTRIAL INSURANCE EXPERIENCE.

The general vital statistics of the iron and steel industry are, for reasons elsewhere discussed at some length, of rather limited practical utility. The most useful data for the United States are the industrial insurance experience statistics of the Prudential Insurance Co., including for the industry considered as a whole, 3,332 deaths from all causes, of which 700, or 21 per cent, were from pulmonary tuberculosis. The details of this experience, on account of the large number of deaths included, are of exceptional interest, and especially so with reference to the younger ages.

TABLE 18.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG IRON AND STEEL WORKERS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, COMPARED WITH THAT OF ALL MALES IN UNITED STATES REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of iron and steel workers, 1897 to 1914, from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Iron and steel workers.	Males in registration area, 1900 to 1913.
15 to 24 years	403	121	30.0	27.0
25 to 34 years	630	215	34.1	30.5
35 to 44 years	684	214	31.3	23.4
45 to 54 years	606	89	14.7	14.7
55 to 64 years	550	48	8.7	7.9
65 years and over	459	13	2.8	2.6
Total, 15 years and over	3,332	700	21.0	13.9

It is shown in Table 18 that the proportionate mortality from pulmonary tuberculosis among iron and steel workers considered as a group is only slightly excessive at ages under 35, but quite decidedly so during the age period 35 to 44, while during the remainder of life the mortality conforms to the normal. Considering that the group represents many widely different occupations, it is self-evident that the data must be interpreted with exceptional caution, but it would seem a safe inference that the physical strain and stress at the younger ages is a factor of some importance in the excessive proportionate mortality from pulmonary tuberculosis at ages 35 to 44. In addition to the relatively high proportionate mortality from pulmonary tuberculosis, pneumonia is also relatively common, the nontuberculous respiratory diseases being accounted for as follows: Asthma, 0.8 per cent; bronchitis, 1.4 per cent; pneumonia, 9.2 per cent; and other respiratory diseases, 1.5 per cent. Combining all the nontuberculous respiratory diseases, it appears that 12.9 per cent of the mortality was caused by diseases of this group, which, combined with the 21 per cent of deaths from pulmonary tuberculosis, indicates that nearly 34 per cent of the mortality from all causes in the iron and steel industry is directly attributable to diseases of the lungs.

The iron and steel workers considered as a group in the mortality experience of the Prudential Co. are made up of puddlers, rollers, heaters, furnace tenders, laborers, and miscellaneous employees. In view of the fact that heretofore no thorough analysis has been presented even of the principal groups of the iron and steel industry, the details of the present analysis are included, even though for certain occupations the data are quite insufficient for a definite conclusion, for, as shown by the table concerning laborers, the large majority of workmen in the iron and steel industry are not further designated as regards the specific occupation followed than that it is stated that they are "laborers at iron and steel works."

MORTALITY OF PUDDLERS.

The mortality of puddlers includes 251 deaths from all causes, 26, or 10.4 per cent, of the deaths being from pulmonary tuberculosis. This low phthisis mortality is of special significance, in view of the relatively high mortality from nontuberculous respiratory diseases, which is accounted for as follows: Asthma, 0.8 per cent; bronchitis, 1.6 per cent; pneumonia, 12 per cent; other respiratory diseases, 2 per cent; and for all nontuberculous respiratory diseases combined, 16.3 per cent; which compares with 12.1 per cent for all occupations in the iron and steel industry. The details for pulmonary tuberculosis are shown in Table 19.

TABLE 19.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG PUDDLERS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, COMPARED WITH THAT OF ALL MALES IN UNITED STATES REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of puddlers, 1897 to 1914, from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Puddlers.	Males in registration area, 1900 to 1913.
15 to 24 years	4			27.0
25 to 34 years	21	4	19.0	30.5
35 to 44 years	36	9	25.0	23.4
45 to 54 years	60	5	8.3	14.7
55 to 64 years	74	5	6.8	7.9
65 years and over	56	3	5.4	2.6
Total, 15 years and over	251	26	10.4	13.9

MORTALITY OF ROLLERS.

The mortality of rollers includes only 112 deaths from all causes, of which 20, or 17.9 per cent, were from pulmonary tuberculosis.

The proportionate mortality was relatively high at ages 35 to 44, as shown by Table 20.

TABLE 20.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG ROLLERS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, COMPARED WITH THAT OF ALL MALES IN UNITED STATES REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of rollers, 1897 to 1914, from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Rollers.	Males in registration area, 1900 to 1913.
15 to 24 years	12	1	8.3	27.0
25 to 34 years	21	6	28.6	30.5
35 to 44 years	17	5	29.4	23.4
45 to 54 years	20	4	20.0	14.7
55 to 64 years	16	3	18.8	7.9
65 years and over	26	1	3.8	2.6
Total, 15 years and over	112	20	17.9	13.9

In addition to the mortality from pulmonary tuberculosis the mortality from other respiratory diseases was accounted for as follows: There were no deaths from asthma, but the mortality from bronchitis was 3.6 per cent; from pneumonia, 8.9 per cent; from other respiratory diseases, 0.9 per cent; and from all nontuberculous respiratory diseases combined, 13.4 per cent, which compares with 16.3 per cent for puddlers, and 12.1 per cent for all employees in the iron and steel industry.

MORTALITY OF HEATERS.

The mortality of heaters is even less representative, in that there were only 51 deaths from all causes, of which 8, or 15.7 per cent, were from pulmonary tuberculosis.

TABLE 21.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG HEATERS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, COMPARED WITH THAT OF ALL MALES IN UNITED STATES REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of heaters, 1897 to 1914, from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Heaters.	Males in registration area, 1900 to 1913.
15 to 24 years	11	3	27.3	27.0
25 to 34 years	6	1	16.7	30.5
35 to 44 years	6	3	50.0	23.4
45 to 54 years	11	....	....	14.7
55 to 64 years	10	1	10.0	7.9
65 years and over	7	....	....	2.6
Total, 15 years and over	51	8	15.7	13.9

In so far as the data can be relied upon the mortality from pulmonary tuberculosis was distinctly excessive. The mortality from nontuberculous respiratory diseases in this group is accounted for as follows: Asthma, 2 per cent; pneumonia, 5.9 per cent; all nontuberculous respiratory diseases combined, 7.8 per cent. There were no deaths from bronchitis or other respiratory diseases.

MORTALITY OF FURNACE TENDERS.

The mortality of furnace tenders is represented by only 62 deaths from all causes, of which 4, or 6.5 per cent, were from pulmonary tuberculosis. The details of the experience are shown in Table 22.

TABLE 22.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG FURNACE TENDERS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, COMPARED WITH THAT OF ALL MALES IN UNITED STATES REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of furnace tenders, 1897 to 1914, from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Furnace tenders.	Males in registration area, 1900 to 1913.
15 to 24 years	4	....	....	27.0
25 to 34 years	7	....	....	30.5
35 to 44 years	11	3	27.3	23.4
45 to 54 years	9	1	11.1	14.7
55 to 64 years	16	....	....	7.9
65 years and over	15	....	....	2.6
Total, 15 years and over	62	4	6.5	13.9

The mortality from other respiratory diseases in this group is accounted for as follows: Pneumonia, 6.5 per cent, and other respiratory diseases, 1.6 per cent; all nontuberculous respiratory diseases combined, 8.1 per cent. There were no deaths from asthma or bronchitis.

MORTALITY OF LABORERS AT IRON AND STEEL WORKS.

Laborers and allied unskilled employments not specifically returned are obviously within the group of general employees at iron and steel works, and they are represented by 2,788 deaths from all causes, of which 628, or 22.5 per cent, were from pulmonary tuberculosis. The details of the experience are shown in Table 23.

TABLE 23.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG LABORERS, ETC., IRON AND STEEL WORKS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, COMPARED WITH THAT OF ALL MALES IN UNITED STATES REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of laborers, etc., 1897 to 1914, from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Laborers.	Males in registration area, 1900 to 1913.
15 to 24 years	361	113	31.3	27.0
25 to 34 years	569	202	35.5	30.5
35 to 44 years	604	189	31.3	23.4
45 to 54 years	492	77	15.7	14.7
55 to 64 years	422	38	9.1	7.9
65 years and over	340	9	2.6	2.6
Total, 15 years and over	2,788	628	22.5	13.9

Of the mortality from other respiratory diseases, 0.8 per cent were deaths from asthma, 1.2 per cent from bronchitis, 9.1 per cent from pneumonia, 1.5 per cent from other respiratory diseases, and 12.6 per cent from all nontuberculous respiratory diseases combined.

MORTALITY OF MISCELLANEOUS EMPLOYEES AT IRON AND STEEL WORKS.

The remaining occupations, including nail makers, forgemen, iron melters, etc., are combined in the group of miscellaneous iron and steel workers in Table 24. There are only 68 deaths reported in this group, of which 14, or 20.6 per cent, were from pulmonary tuberculosis.

TABLE 24.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG MISCELLANEOUS IRON AND STEEL WORKERS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, COMPARED WITH THAT OF ALL MALES IN UNITED STATES REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of miscellaneous iron and steel workers, 1897 to 1914 from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Miscellaneous iron and steel workers.	Males in registration area, 1900 to 1913.
15 to 24 years	11	4	36.4	27.0
25 to 34 years	6	2	33.3	30.5
35 to 44 years	10	5	50.0	23.4
45 to 54 years	14	2	14.3	14.7
55 to 64 years	12	1	8.3	7.9
65 years and over	15	....	....	2.6
Total, 15 years and over	68	14	20.6	13.9

The excessive mortality from pulmonary tuberculosis in this group is of special significance, in that most of the men are exposed to arduous strain, heat, dust, weather changes, etc. The mortality from other respiratory diseases in this group is as follows: Asthma, 2.9 per cent; bronchitis, 7.4 per cent; pneumonia, 10.2 per cent; or, from all nontuberculous respiratory diseases combined, 20.6 per cent. It is, therefore, shown that both tuberculous and nontuberculous lung diseases are proportionately more common in this relatively small but important group, however ill defined, than among heaters, furnace tenders, rollers, and puddlers.

EVIDENCE OF UNSATISFACTORY HEALTH CONDITIONS.

The experience, of course, is too limited for entirely safe conclusions, but it is distinctly suggestive of more or less unsatisfactory health conditions, apparently predisposing to both pulmonary tuberculosis and nontuberculous respiratory diseases. It is, therefore, regrettable that there should be no other statistics useful for the present purpose, for regardless of the considerable development of the iron and steel industry in England and Wales, the employees are not separately returned, except under the rather general term of nail, anchor, chain, and other iron and steel manufactures. This group included, according to the census of 1901, 220,000 males above the age of 15 years, of whom 216,000 were actively at work. It is said in the report of the registrar-general that—

> In this industry the mortality at every stage of life is above the standard for occupied and retired males, the excess ranging from 4 per cent at ages 20 to 25, to 25 per cent at ages 65 and upward. At every stage of life the death rate exceeds the average for metal workers generally. In the main working period the comparative mortality figure is 1,187, or 18 per cent above the standard. These workers appear to suffer heavily from influenza and respiratory diseases, the former being above the standard by 29 per cent and the latter by 79 per cent. The mortality from diseases of the circulatory system is also above the average by one-fifth part, but on the other hand that from alcoholism and liver disease and from suicide is below the standard.

It should be said, however, in this connection that there has been a marked decline in the mortality of the group under consideration during the preceding decade, equivalent to a reduction of nearly 25 per cent, the decline having occurred in practically every group of diseases excepting cancer. The decline was most noticeable in the case of influenza, phthisis, and respiratory diseases. The data, however, must be used with caution in view of the fact that the group includes too many widely different industries and employments to be strictly representative for any one of them.

ENGLISH MORTALITY STATISTICS.

The same observations, unfortunately, apply to other important occupations in the iron and steel industry with more or less exposure to metallic dust, combined in a single group in the official English statistics under "Engine, machine, boiler makers; fitters, millwrights, engine fitters, etc." This group in 1901 was represented by 351,000 persons, of whom 345,000 were actively at work. It is said with reference to this group that—

In these occupations taken together the death rates were below the standard for occupied and retired males at every age group except 55 to 65 years, the rates for boiler makers being below those for engine fitters at ages under 25 and over 65 years but above them throughout the main working period of life. The comparative mortality figure from all causes was 913, or 9 per cent below the standard; the figure for engine makers being 893, or 11 per cent below the average, while that for boiler makers was 1,032, or 3 per cent above it. Among these workers collectively the mortality from nervous diseases slightly exceeded the standard, but from digestive diseases and from accident and suicide their mortality was below it. If the figures for engine fitters and boiler makers be compared, it will be seen that the first-mentioned workers experienced higher mortality than the latter from influenza, phthisis, and Bright's disease, but under every other heading the mortality of boiler makers exceeded that of engine fitters. Engine fitters appear indeed to be by far the healthiest section in the entire class of metal workers.

The preceding observations can not be said to apply with even approximate conclusiveness to the iron and steel industry as the term is generally understood and used in the United States. Most of the occupations involve a fair amount of metallic-dust exposure which under given conditions, such as, for illustration, in the case of boiler makers, may assume serious consequences. The relative mortality from phthisis among engine makers, fitters, millwrights, etc., or what in the United States would generally be considered machinists, in the broad sense of the term, was only 88 against 100 for occupied and retired males, and the corresponding mortality from nontuberculous respiratory diseases was only 85; but for boiler makers the relative mortality from phthisis was 80, while for nontuberculous respiratory diseases it was 119. In contrast, it may be pointed out that the relative mortality from phthisis for cutlers and scissors makers was 285, and for file makers, 207. It may further be said in this connection that the relative mortality from nontuberculous respiratory diseases was 178 for cutlers and scissors makers, and 184 for file makers. In each and every comparison of this kind the mortality of occupied and retired males from the diseases stated is taken as 100.

RECENT ENGLISH OCCUPATIONAL-DISEASE INVESTIGATIONS.

Some exceptionally interesting observations on "Industrial diseases prevailing amongst iron and steel workers in the Middlesbrough district of England," by J. Watkin Edwards, have been made available through the British Medical Journal (July 22, 1916). In a brief outline of the conditions which influence life and health in industry it is observed that—

(*a*) The effects of overcrowding are more harmful during active work than when workers are at rest; and

(*b*) The evils of overcrowding are aggravated by:

(1) Exposure to changes of temperature;
(2) Inhalation of dust and irritating particles;
(3) Absorption of chemical poisons; and
(4) The effects of undue strain and exertion.

A formula is presented according to which if the amount of air inspired while at rest equals 1, the amount inspired when standing erect is 1.3, and while walking at the rate of 4 miles per hour is 5. It is, therefore, suggested that every effort should be made in industrial towns toward making the lot of the workmen, both while at work and when off work, as perfect as possible. In the district of Middlesbrough pneumonia prevails to an alarming extent, being nearly four times as frequent as pulmonary tuberculosis, and more than three times as common as bronchitis. It is explained, however, that "these figures do not at all fully represent the amount of industrial disease prevailing in the town for there are many minor complaints which do not appear as causes of death, but which give patients a great deal of pain and practitioners a great deal of trouble." The local adverse influences which appear to affect the general death rate, especially with reference to the mortality from industrial diseases, are said to be:

(1) Working at high temperatures.
(2) Long hours of work, fatigue, insufficient rest, sleep, and recreation.
(3) Working at night.
(4) Careless exposure to cold and wet.
(5) Intemperance.
(6) Inhalation of dust.
(7) Inhalation of poisonous gases, such as CO.
(8) Trauma.

With special reference to pulmonary tuberculosis it is stated that—

This condition was the cause of 70 deaths amongst males. The causes which lie at the root of its prevalence are:

(*a*) Inhalation of dust at the works (where it is chiefly composed of inorganic particles), but especially in our streets and dwellings and places where people congregate. The disease known as pneumoconiosis is known to kill large numbers of Staffordshire potters, Cornish and Transvaal miners, and Sheffield grinders. Dust from any cause, especially that produced in the manufacture of manure from basic slag, causes bronchitis, asthma, chronic cough and emphysema, and pneumonia, and, no doubt, predisposes the body to the attacks of the tubercle bacillus. As these dust diseases develop insidiously, the workmen engaged in such occupations should have their chests examined periodically, and any signs of commencing disease should be regarded as a disqualification for that particular kind of employment.

MORTALITY FROM PNEUMONIA AMONG ENGLISH IRON AND STEEL WORKERS.

On account of the exceptional mortality from pneumonia among males in the Middlesbrough district, it is of interest to note that during the working period of life, that is, ages 25 to 65, the death rate in the county boroughs of the North of England was 1.6 per 1,000; in Sheffield it was 1.2 per 1,000; in Middlesbrough, among females, 0.9 per 1,000; and in Middlesbrough, among males, 3.4 per 1,000. It is said in this connection that "The death rate from pneumonia in Middlesbrough is between two and three times higher than in the county boroughs of the North, in Sheffield, and in the country generally among males between the ages of 25 and 65 years, while it is between three and four times higher than that among females in Middlesbrough." With respect to possible occupational causes, in explanation of the excessive mortality from pneumonia, the following conditions are emphasized:

(*a*) Working in high temperatures with sudden exposure to cold, strong currents of air, and to powerful blasts of fiery and suffocating gases.

(*b*) Inhalation of dust of various kinds, and especially dust given off in the manufacture of slag manure.

(*c*) Injuries of any kind, especially to the chest.

(*d*) Excessive fatigue, especially after nightwork.

(*e*) Careless habits after leaving work.

(*f*) Intemperance in food and drink.

In the majority of cases it is held that "the disease is conveyed by autoinfection. A condition of lowered resistance, due to one or more of the above causes, furnishes a state of ill health favorable to the growth of an organism either already present in the mouth or throat of the patient or inhaled with dust or bad air." It is therefore suggested that patients who have suffered from pneumonia (as well as those who have not) should exercise the greatest care in keeping their teeth, mouth, and throat in a healthy condition. On account of the fact that pneumonia in Middlesbrough is of a very fatal type, accounting for one-fifth of all the deaths in 1911, it is advised that—

The sputum should be carefully destroyed as soon as possible. For this purpose the patient should expectorate into squares of paper or into small cardboard receptacles containing a layer of common salt or other suitable disinfectant, and the whole destroyed at frequent intervals by fire. Every reasonable care should be taken to prevent the patient coughing into the faces of the attendants, or onto the bedclothes, or upon the floor; such accidents frequently happen, especially in the case of semiconscious patients. The infected spots should be scrupulously cleaned with turpentine or spirit, and the clothing of the nurses and of those in attendance should be protected by overalls. The rooms in which pneumonia patients have been treated should be thoroughly disinfected, and I am glad to observe that this is now being undertaken by the municipality.

GENERAL CONCLUSIONS.

The foregoing observations regarding pneumonia are of special importance in view of the obvious conclusion that the disease is unquestionably increased in frequency and possibly in severity by more or less continuous and considerable exposure to irritating metallic and mineral dust. That similar conditions prevail, though probably to a lesser degree, in the United States is made evident by a recently issued technical paper by the United States Bureau of Mines on Health Conservation at Steel Mills, by J. A. Watkins, of the United States Public Health Service. The paper includes observations on the medical supervision of employees, hospital facilities, fatigue as a cause of occupational disability, the relation of industrial buildings to the health of employees, noise as a cause of lowered efficiency, ventilation, temperature and humidity, hours of duty, washing and sanitary facilities, drinking water, food, etc. There are, however, no observations in this interesting discussion on industrial diseases as such, and no reference whatever to the dust menace as common to a number of special processes in the iron and steel industry, chiefly, of course, in grinding and polishing during the final processes of manufacture. The discussion is, therefore, general and has reference rather to sanitary conditions than to occupational hazards, and a much more specialized investigation would be necessary to establish the occupational-disease hazard in the American steel industry as carried on under modern conditions at such model plants as that at Gary, Ind., of which an admirable descriptive account was published in the Engineering and Mining Journal for December 26, 1908.

METAL GRINDERS.

THE HYGIENE OF METAL GRINDING.

The grinding trade includes a large variety of employments, of which metal grinding, by either the dry or wet process, is hygienically as well as industrially the most important. The grinding of metal probably involves as much exposure to decidedly health-injurious conditions as does any other employment, if not more so. Chiefly as the result of the inhalation of relatively large quantities of fine metallic dust, and not inconsiderable quantities of fine mineral dust, the mortality from pulmonary tuberculosis in this occupation is decidedly above the normal for occupied males generally. While the sanitary and other conditions injuriously affecting the health of metal grinders never have been so notoriously bad in the United States as in England or in continental Europe, the observed mortality of this occupation as carried on in this country fully warrants the most serious conclusions as to the health-injurious effects of this group of employments.

The mortality of metal grinders has been discussed by James H. Lloyd, M. D., in his treatise on "Diseases of occupations," included in the Twentieth Century Practice of Medicine, published in 1895. Lloyd, after calling attention to the well-known fact that the trade of the grinder is conspicuous above all others for the suffering that is entailed from the inhalation of metallic dust, describes in detail the different processes of grinding and their relation to health. He says in part:

> Grinding edge tools is of two kinds—wet and dry. The latter method is by far the more injurious, as, naturally, it raises far the greater amount of dust. For some tools both methods are used—the mixed method. The tools ground are scythes, saws, table knives, machine knives, various other kinds of edge tools, files, penknives, razors, scissors, forks, needles, etc. A great difference in their bad effects is observed among the branches of the trade according as the grinders use the wet or dry method and according to the tool ground. The smaller objects are far the most trying and exacting upon health. The worst of all branches are the fork grinding and needle grinding. This is because in grinding these small objects the workman is obliged to lean close over the stone and therefore inhales large quantities of the dust, and also because the dry grinding is used.
>
> The dust raised by grinding is composed largely of minute bits of steel. According to Hall, 12 razor blades forged in the rough, which weigh 2 pounds and 4 ounces, lose 10 ounces in the process of grinding. This loss represents so much fine metallic dust, mingled of course with dust from the stone. This statement gives some idea of the immense amount of dust produced by dry grinding. According to Holland the concrete masses of this dust formed in needle grinding have almost the specific gravity of iron.

TYPICAL DISEASES OF GRINDERS.

In discussing the symptoms of the diseases typical of grinders as the result of their employment, Lloyd points out further that—

> They are those of a slowly advancing bronchitis with asthma and sometimes with emphysema; later dilated bronchi with excavation are observed; then, consolidation, and breaking down of lung tissue

occur as the terminal processes. The exact relationship of these processes to a tubercular infection in grinders is an interesting and important subject, which, of course, did not receive much light from the earlier writers. They endeavored, in fact, to draw distinctions between true "consumption" and grinders' "asthma," but the state of pathological knowledge in their day was not such as to permit them to do otherwise. It is quite evident from reading their reports of cases that they had to do with a disease that was essentially tubercular, but it would be interesting to have the exact relationship of this infection to the grinders' unwholesome occupation investigated by the methods of modern bacteriology. I do not know whether this has ever been done. There can be no doubt that the influence of the grinder's trade is that of a predisposing cause. The inhalation of the irritating particles of steel into the lungs causes a constant catarrhal bronchitis and pneumonitis, with increase of connective tissue; and this prepares the soil for a tubercular infection which characterizes the latter stages of the disease.

INJURIOUSNESS OF DRY-GRINDING PROCESSES.

A recent and more qualified discussion of the health-injurious circumstances of dry and wet grinding is by Oliver, who, in his Diseases of Occupation, goes fully into all the details concerning the trade, including a brief account of the corresponding conditions in the cutlery manufacture of Germany, at Solingen:

> So far as the two methods of grinding cutlery are concerned, the dry method is, from a health point of view, the more dangerous to the workers. The dust is dry, and is in the form of a very fine powder, which readily reaches the lungs owing to the attitude of the men when at work. Steel grinders sit astride the grinding stone on a saddle, and as they lean forward keeping close to their work, they can not but inhale some of the dust, which is a mixture of steel and stone. Forks and needles are generally ground by the dry method; knives, scissors, and razors by the wet. Some are ground by both methods, e. g., the backs of razors and scissors are ground by the dry method and the remainder of the blade by the wet. It was in 1865 that Dr. T. C. Hall, of Sheffield, drew attention to the high death rate of steel grinders from pulmonary phthisis. The average age at death of steel grinders was at this period only 29 years, but of late this has improved. Dr. Hall's statistics referred to dry grinding. In wet grinding the running stone passes through a thin layer of water in a trough below the stone, so that, as its surface is always kept wet, comparatively little dust is given off during the process of grinding; but while the atmosphere is clearer of dust, the floors and walls of the workshop are damp and cold. The grinding is carried on in rooms called "hulls," which are bounded by three blank walls; the windows are without glass. Where dry grinding is carried on there are fans, but these often prove ineffective. It is no uncommon thing to find men engaged in different processes in one large room, so that the dust which is generated affects not only the workman sitting at his own grinding stone, but the other inmates of the room as well. In Sheffield it has been ascertained that in

every 1,000 deaths among steel grinders pulmonary phthisis is the cause of 345 and other respiratory diseases 295; that is, collectively pulmonary diseases account for 64 per cent of the entire mortality, whereas among the adult population of the country generally phthisis accounts for 144 deaths per 1,000 and other respiratory diseases 182, or collectively 32.6 per cent. Steel grinders die comparatively young. Dr. Sinclair White, in Dangerous Trades, page 414, says that 458 grinders in every 1,000 die between the ages of 35 and 55, compared with 261 in every 1,000 of the entire male population of the country. Only 140 grinders out of every 1,000 reach the age of 55 and upward, whereas for every 1,000 of the adult male population 391 reach 55 years and upward. Sinclair White is of the opinion that phthisis is not so rife among steel grinders as formerly. In Dr. Hall's time the average age at death from phthisis was 29 years; at present it is 43.[1]

IMPROVEMENT IN THE HEALTH OF GERMAN CUTLERY GRINDERS.[2]

With reference to conditions in Germany and the remarkable improvement which has followed the introduction of sanitary precautions, rational methods of ventilation, and other means of dust prevention, Oliver holds:

In the town of Solingen and the neighborhood it is estimated that there are 29,000 persons employed in making cutlery. Here all sorts of steel goods are made—knives, forks, scissors, and swords. A good deal of the work is done by the people in their homes, and it is interesting to know that the home industry is rather encouraged by the local authority, which provides the men with gas and electric power. So prevalent is pulmonary consumption among the grinders in Solingen that it has attracted the attention of the Government factory department. In the 10 years 1885–1895, 72.5 per cent of the deaths among knife grinders in the Solingen district was due to phthisis, against 35.3 per cent for the rest of the population over 14 years of age, and an official examination showed that out of 1,250 grinders only 85 men were over 45 years of age. Dr. Shadwell speaks approvingly of the methods adopted in some of the Solingen factories to deal with the removal of dust. Oldendorf, in writing about the grinders at Solingen, states that 24.7 per cent reached 50 years of age and 3.3 per cent 70; that at Runsched 33.8 per cent reached 50 years and 8 per cent 70; while at Kronenberg the numbers were 32.9 and 8.7, respectively. The mean age at death of grinders employed in the dry methods was 39.4, of workers in iron 48.3, and of the rest of the male population 54.4 years. Taking all ages, the deaths from tuberculosis per 100 cases were for grinders 78.3, iron workers 59, other persons 46.[3]

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[1] Diseases of Occupation, Thomas Oliver, pp. 230. 231, London, 1908.

[2] In this connection see "Gesundheitsbuch für die Kleineisen-Industrie," von Dr. G. D. Orthmann, Berlin, 1899; "Gewerbliche Gesundheitspflege," von Dr. A. Bender, Stuttgart, 1906: "Handbuch der Arbeiterkrankheiten," von Dr. Theodor Weyl, Jena, 1908.

[3] Diseases of Occupation, Thomas Oliver, p. 232.

SANITARY PRECAUTIONS IN GERMAN CUTLERY SHOPS.

A very interesting account of the mortality of cutlery grinders in Solingen was also included in the Report of the Chief Inspector of Factories and Workshops of England for 1906, from which an abstract is made to emphasize the sanitary and labor conditions required for the reduction of the mortality of grinders to a minimum:

> The atmosphere of Solingen is bright and clear. It is seldom that black smoke is seen escaping from the factory chimneys. This is largely the result of careful firing and the use of coal briquettes instead of ordinary coal, which avoids the use of slack coal. The day's actual work is nine hours; on Saturday work ceases at 5.30 p. m. The factories in Solingen are said to be marvels of order and cleanliness; the floors are of concrete and the air space for each worker must be at least 565 cubic feet. All the grinding stones are protected by guards. The walls of the workrooms are limewashed every year; the floors are swept every evening and damp-wiped once a week. The "raising" of grindstones is never undertaken during working hours except under a stream of water or unless the stone is entirely inclosed in casing except at the working place of the raising tool. The floors are kept clean and provision is made for the removal of the dust during grinding. Cutlery manufacture is recognized as a dangerous trade in Solingen, and in recent years considerable improvement has taken place in the means to prevent dust. In Solingen the grindstones and polishing wheels are run toward the worker; in Sheffield they are run away from the worker, so that the dust has an upward tendency and flies into the room.[1]

The subject is also considered in the Report of the Chief Inspector of Factories and Workshops for 1907, in which the rules or police regulations governing the trade at Solingen are republished in full. A remarkable improvement in the health of the workmen has followed the introduction of these rules.[2]

MORTALITY OF SHEFFIELD METAL GRINDERS.

Some exceptionally interesting and useful mortality data of metal grinders have been published for a period of years by the city of Sheffield, England, but unfortunately the statistics were discontinued subsequently to 1910. Table 25 shows the mortality in detail of 2,490 grinders, of whom 1,070, or 43 per cent, died from pulmonary tuberculosis, with an additional mortality of 621, or 24.9 per cent, from nontuberculous respiratory diseases.

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[1] Report of the Chief Inspector of Factories and Workshops, 1906, pp. 107–109.

[2] For additional references on the occupational diseases of German file makers and related industries, see Albrecht, Handbuch der Praktischen Gewerbehygiene, Berlin, 1896, pp. 96 and 796; Sommerfeld, Handbuch der Gewerbekrankheiten, Berlin, 1898, p. 365 (including statement that average age at death for file cutters dying from pulmonary tuberculosis was only 41.2 years and from all other diseases 46.1 years). Of special importance is the more extended discussion of this occupation in Weyl's Handbuch der Arbeiterkrankheiten, Jena, 1908, pp. 80, 91, 106, 135 et seq.

TABLE 25.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AND FROM OTHER RESPIRATORY DISEASES COMPARED WITH THAT FROM ALL CAUSES, AMONG GRINDERS IN SHEFFIELD, ENGLAND, 1889 TO 1910, BY AGE GROUPS.

[Source: Annual reports of the medical officer of health, Sheffield, England. Similar returns are not available in these reports subsequent to 1910.]

Age at death.	Deaths from all causes.	Deaths from pulmonary tuberculosis.		Deaths from respiratory diseases other than pulmonary tuberculosis.	
		Number.	Per cent of deaths from all causes.	Number.	Per cent of deaths from all causes.
Under 25 years	98	43	43.9	22	22.4
25 to 34 years	299	173	57.9	51	17.1
35 to 44 years	515	303	58.8	81	15.7
45 to 54 years	687	336	48.9	169	24.6
55 to 64 years	548	178	32.5	184	33.6
65 years and over	343	37	10.8	114	33.2
Total	2,490	1,070	43.0	621	24.9

According to this table, at ages under 25 of every 100 deaths from all causes 43.9 are from pulmonary tuberculosis, the proportion increasing to 57.9 per cent at ages 25 to 34, and 58.8 per cent at ages 35 to 44. Subsequently to this period the proportion declines to 48.9 per cent at ages 45 to 54, and to 32.5 per cent at ages 55 to 64; at ages 65 and over the proportion of deaths from pulmonary tuberculosis is only 10.8 per cent of the mortality from all causes. The corresponding mortality from nontuberculous respiratory diseases must also be considered excessive at practically every period of life.

In view of the frequent use of the term "grinders' phthisis," as based chiefly upon the morbidity experience of Sheffield grinders,[1] the following observations by J. M. Beattie, M. D., are of interest. The extract is from a paper on the "Hygiene of the steel trade," published in the Transactions of the Royal Sanitary Institute for 1912:

> A great deal of attention has been centered on the dust problem, and much of the legislation relating to the industries with which we are dealing is concerned with the protection of the workers from dust inhalation. The much more serious problem—the prevention of infection with *B. tuberculosis*—has not received justice at the hands of factory inspectors and factory legislators. During a five years' experience in Sheffield it has been abundantly demonstrated that the cutlers and grinders die from tuberculosis and not from nontuberculous fibrosis of the lung.
>
> Let me protest against the loose use of the word "phthisis." Rightly or wrongly, phthisis is now understood by medical men to mean

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[1] Regarding health conditions among Sheffield grinders see "The Vital Statistics of Sheffield," by G. C. Holland, M. D., London, 1843, pp. 152–205; "Unhealthy Trades," by B. W. Richardson, Lectures before the Society of Arts. Reprinted in Scientific American Supplement No. 9 (Feb. 26, 1876); "Mortality of Dusty Trades in Sheffield," by Scurfield. British Medical Journal, Aug. 22, 1908, p. 480; "Annual Reports on the Health of Sheffield, England," Special Tables and Observations on Mortality in Sheffield Trades, 1889–1907.

tuberculosis of the lung with cavity formation; and the term "grinders' phthisis" should be confined to that condition of the lung in which tuberculosis is added to the interstitial fibrosis. For the condition which is produced by the inhalation of dust, the term "fibrosis" is perhaps the most suitable; I shall, therefore, describe the condition resulting from the inhalation of dust as fibrosis. The misuse of the term "phthisis" makes it difficult to get at satisfactory statistics, and we can therefore only regard the figures given as approximate.

MORTALITY OF GRINDERS—INDUSTRIAL INSURANCE EXPERIENCE.

No extended scientific study, medical or otherwise, has been made of grinders' phthisis, or the occurrence of pulmonary tuberculosis among the grinders in the United States, but some suggestive observations on different aspects of the grinders' trade have been reported upon in detail by the division of occupational diseases of the Ohio State Board of Health. The only conclusive mortality data for the United States are the industrial insurance mortality statistics of the Prudential Insurance Co., limited, however, to 305 deaths, of which 143, or 46.9 per cent, were caused by pulmonary tuberculosis. This percentage is not much at variance with the corresponding figure for Sheffield grinders, but is, in part, no doubt, the result of important differences in age distribution, since the maximum number of deaths in the United States occurred at ages 35 to 44, against ages 45 to 54 in the English experience. The excess in the mortality of grinders from pulmonary tuberculosis is brought out with sufficient clearness and conclusiveness in Table 26, in which comparison is made with the corresponding mortality of males in the registration area.

TABLE 26.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG GRINDERS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, COMPARED WITH THAT OF ALL MALES IN UNITED STATES REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of grinders, 1897 to 1914, due to—		Per cent of deaths due to pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Grinders.	Males in registration area, 1900 to 1913.
15 to 24 years	17	7	41.2	27.0
25 to 34 years	56	38	67.9	30.5
35 to 44 years	74	44	59.5	23.4
45 to 54 years	73	35	47.9	14.7
55 to 64 years	55	14	25.5	7.9
65 years and over	30	5	16.7	2.6
Total, 15 years and over	305	143	46.9	13.9

According to this table, the proportionate mortality of grinders from pulmonary tuberculosis is excessive at all ages, but most pronounced at ages 25 to 34, when out of every 100 deaths from all causes, 67.9 are from pulmonary tuberculosis, against 30.5 per cent for males in the registration area. The data, while limited, may be accepted as trustworthy regarding the mortality of grinders from pulmonary tuberculosis in the United States at the present time. The evidence is sufficient to show that the disease is of excessive frequency among grinders at every divisional period of life, and very considerably above the normal for the general male population.

MORTALITY OF INSURED GRINDERS—MEDICO-ACTUARIAL EXPERIENCE.

The foregoing observations are sustained by the medico-actuarial experience, which, however, is only with reference to the mortality from all causes. According to this experience, which includes cutlers, scissors grinders, ax, plow, and other steel grinders, but excludes foremen and superintendents, the actual mortality among 5,988 employees exposed to risk one year was 43 deaths, while the expected mortality was 36.69, or 17 per cent in excess; in other words, to every 100 deaths expected on the basis of the normal experience there were among the group considered 117. When the age factor, however, is taken into account, it appears that at ages under 40 the actual mortality was less than the expected, while there was a rapid and very considerable rise in the excess at ages over 40. Unfortunately, the numbers under observation are insufficient for strictly scientific conclusions. The results, in detail, are given in Table 27.

TABLE 27.—MORTALITY FROM ALL CAUSES AMONG CUTLERS AND SCISSORS, AX, PLOW, AND OTHER STEEL GRINDERS (EXCLUDING FOREMEN AND SUPERINTENDENTS), BY AGE GROUPS—MEDICO-ACTUARIAL INVESTIGATION.

Age at death.	Number exposed to risk 1 year.	Actual deaths.	Expected deaths.	Ratio of actual to expected deaths.
15 to 29 years	3,208	12	14.55	82
30 to 39 years	1,841	9	10.19	88
40 to 49 years	667	10	6.17	162
50 to 59 years	254	12	5.04	238
60 years and over	18	....	.74	....
Total	5,988	43	36.69	117

SANITARY INVESTIGATIONS BY THE OHIO STATE BOARD OF HEALTH.

Some very useful observations on the health of grinders have been included in the report of the Ohio State Board of Health, by Hayhurst, who points out that—

> The process of metal grinding is one closely associated with foundry work and assembling processes upon both iron and soft metals. It properly includes also the dressing of castings by other means than grinding, such as "sand blasting," "rattling" in tumbling machines, and "chipping" by means of steel tools. Sand blasting has been considered elsewhere, while a word will be given here to each of the other subsidiary processes. Metal grinding is usually performed with emery wheels, which may be stationary or may be moved about over large surfaces by means of a swing-belt attachment. Oc-

casionally it is done mechanically by a series of traveling emery wheels, which pass up and down over the surfaces to be ground. Sometimes it is done by belts covered with emery or other exceedingly hard abrasive substances. Carborundum and corundum, two substances of diamondlike hardness, are the chief abrasives used.

In the investigation by Hayhurst, including 64 establishments employing a total of 1,979 male wage earners, modern methods of work were observed in 42 places, fairly modern methods in 14, and crude or antiquated methods in the remaining 8. Health appliances, especially those consisting of blower systems to remove the dust created, were considered good in 20 places, of only partial efficiency in 13, and found entirely absent in the remaining 31. In 20 of the work places other processes than metal grinding were carried on in the same quarters, such as sand blasting, forging, welding, polishing, buffing, etc. This condition is quite common throughout the dusty trades, and illustrates the difficulty, if not the impossibility, of completely separating one injurious process from another. As a broad generalization, however, the present classification may be considered sufficient for the purpose. The Hayhurst investigation, while limited to the State of Ohio, may be considered fairly conclusive for the country at large, although it is pointed out that—

> It is probable that country-wide statistics would be much more accurate, both because of the larger number of deaths and because persons with bronchial or respiratory diseases have a strong tendency to migrate to western States.

MORTALITY EXPERIENCE OF THE STOVE MOUNTERS' INTERNATIONAL UNION.

The investigation concludes with an interesting table of statistics derived from a report submitted by the Stove Mounters' International Union for the United States and Canada. These workers are engaged only about one-fifth of their time in metal grinding, and usually they are employed without the advantage of any protective devices whatever. Most of the time, however, they work in an atmosphere more or less contaminated with fine metallic and mineral dust. Table 28 is as follows:

TABLE 28.—PER CENT OF DEATHS FROM EACH SPECIFIED CAUSE AMONG STOVE MOUNTERS TO WHOM DEATH BENEFITS HAVE BEEN PAID BY THEIR ORGANIZATION DURING THE PAST FIVE YEARS, IN THE UNITED STATES AND CANADA (UNDER DATE OF SEPT. 17, 1914).

Cause of death.	Per cent.
Tuberculosis	27.95
Heart disease	20.93
Accident	11.67
Pneumonia	9.31
Other preventable causes	13.88
Degenerative diseases	9.23
All other causes	7.03
Total	100.00

GENERAL CONCLUSIONS.

The available evidence is, therefore, sufficiently conclusive that metal grinding in probably any and all of its various forms must be considered one of the most injurious occupations inciting a special predisposition of the workers to tuberculous and nontuberculous respiratory diseases. Aside therefrom, the Hayhurst investigation ascertained in 17 plants an occurrence of 22 cases of industrial diseases, as follows: Chronic lead poisoning, 5 cases; pulmonary siderosis, 9; frequent attacks of brass poisoning, 2; bronchitis, 2; pneumonia, 1; tuberculous empyema, 1; brush burns of the hands, 1; conjunctivitis, 1.

The results seem to indicate generally unsatisfactory working conditions, and they sustain the statement made by Hayhurst that—

> The better control of the dust is the first essential, while shorter work hours, alternation of work to overcome monotony, and the features mentioned under the respective hazards above, as well as medical examination and supervision, are necessary to control health in this entirely unnatural and hazardous process.

Concerning the conflicting character of the official vital statistics of grinders, it is stated in this connection, in the report on the draft regulations proposed to be made for factories in which the grinding of metals and the racing of grindstones is carried on, by Alfred Herbert Lush (Parliamentary paper Cd. 4913, London, 1909) that—

> The figures were not in all respects easy to reconcile; but it was clearly established that both the wet and the dry grinders were affected by diseases of the respiratory organs, and especially by fibrosis of the lungs and by phthisis, to an extent far beyond the average of occupied males, the mortality from phthisis amongst them being six times that average. The men who enter these trades are usually above the ordinary standard of physique and vigor, because weakly men are unsuited to the work; yet the proportion of damaged lives found by Dr. Collis was very heavy, and the duration of life is nearly the lowest of all the trades. The cutlers, who are said to be as a rule of weaker physique to begin with, suffer less from phthisis and have longer lives; but they appear to be more liable to the minor diseases due to dust irritation, and in no respect can their health conditions be considered satisfactory.

This report is an exceptionally valuable contribution to the practical study of dusty trades, and should be consulted in further amplification of the observations on the special circumstances and conditions tending to increase the exceptional liability of grinders to pulmonary tuberculosis.[1]

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[1] See in this connection "The story of the grinding wheel," by C. W. Blakeslee, in The Iron Age, reprinted in the Scientific American Supplement No. 2125, Sept. 23, 1916. Mention should also be made of the report on the draft regulations proposed for factories and workshops in which the process of file cutting by hand is carried on, by Chester Jones (Parliamentary paper Cd. 1658, London, 1903).

POLISHERS.

The polishing of metal ware is a widely diversified trade, and the term "polisher" is one of general rather than of special significance. Under the term are included metal polishers and buffers working upon steel, brass, gold, and silverware, but no data are available which would permit of a proper classification of polishers according to the metal or material manipulated.

POLISHING PROCESSES IN RELATION TO DUST.

The health-injurious effects of this employment have been recognized by all who have written upon the mortality of dusty trades, and the more important facts are summarized by Arlidge, in part, as follows:

> After being shaped and ground to the required dimensions, the next business is to burnish or polish the articles. This is accomplished by wheels covered by leather, and also by a thick bundle of linen rags cut and bound together in the form of a wheel, and which, by rapid rotation, assumes the character of a solid mass, and, at the same time, one so soft as to serve better than any other contrivance for the purpose of surface polishing. To assist in giving polish to the articles made, various powders are employed; for example, emery, whiting, rouge, powdered pumice, etc. The use of these materials adds vastly to the dust of the trade and to its pernicious results; but no data are in existence to indicate what is its share in the causation of disease as compared with the dust of the grindstones. Still, no question exists that these polishing powders, differing as they do among themselves in physical qualities, differ likewise in the range of their effects upon the lungs.

The rather involved circumstances affecting the polishers' health and mortality are also discussed in The Workers of the Nation, by Mr. Gilson Willets, whose attention appears to have been attracted by the particularly health-injurious conditions of the employment, and whose conclusions are decidedly suggestive:

> Metal polishers who have reached the age of 40 often look like old men. There can hardly be found a trade more deleterious to health, say those who follow it. Among the harmful conditions may be mentioned the liability of the workmen to get their lungs full of flying and impalpable dust, which is composed of metal, minerals, and cotton fiber. They are also, in many cases, deprived of the proper supply of light, and great injury to the eyes thus arises. It is not easy to wear goggles or glasses, as the operator's sight must be of the keenest in order to detect blemishes. There are laws for the protection of this class of workmen, but they are too seldom employed. New York statutes require that at each polishing lathe there shall be an exhaust fan to carry off the dust, that each operative shall have 250 cubic feet of air space, and plenty of light. It has been claimed that not in 5 per cent of the shops do these desirable provisions prevail. A buffing wheel, making 2,500 revolutions per

minute, has wrecked many constitutions. From it, as the polisher applies the metal, a cloud of dust arises, made of particles of cloth and metal, and that is what the operator breathes. Generally the windows are hermetically sealed. Often the walls and floors are covered with the accumulation of years. In the process of brightening silver-plated material there is given forth by the wheel a cloud of dust of which crocus is a large constituent, while from the plating room come fumes of nitric acid. In the process of polishing chandeliers there is much dust set free, which is composed of particles of brass, and permeates the air of the shop. Metal polishers often do not care to complain, because their wages are high. Here is a good field for activity among the factory inspectors, who should force employers to maintain proper conditions in the shops.[1]

SICKNESS EXPERIENCE OF THE METAL POLISHERS' UNION.

More recent evidence has been presented in the published sickness and mortality experience of the Metal Polishers' Union, regarding which it has been stated that—

> The treasury of this union, in spite of the fact that the men are steady and have no special temptations to excess, was found to be constantly exhausted. The reason is that the death claims eat up all the funds. An investigation of these claims showed that many of the men were dying from pulmonary tuberculosis. There were some deaths from accident, a few suicides, but the rest were all from pulmonary diseases—and pneumonia was very rare as compared with phthisis. The statistics for the last four years show that in 1903, 45 metal polishers died, of whom 43 succumbed to some lung trouble. In 1904 there were but 38 deaths among the metal polishers, of which only 3 were due to other causes than pulmonary disease. In 1905 there were 70 deaths among the metal polishers, 65 of which were due to some form of lung trouble. In New York City a local union having 170 men working exclusively on the precious metals had 8 death claims in two years, 7 being due directly to tuberculosis, while 400 men employed in all the other branches of the same industry have had but 3 deaths from this cause in the same space of time.

A medical journal, commenting upon the above-quoted facts at the time of their publication, argued very pointedly to the effect that—

> It would seem from these statistics that even the cleanest kinds of dust, without a trace of infectious material in them, may still prove a source of the greatest possible danger and be the indirect cause of tuberculosis. This has been known for some time, but so startling a confirmation of it is sure to emphasize the necessity for taking every precaution for the avoidance of dust. Even what might seem to be the most innocuous of dirt particles may, when inspired, constitute foci of irritation in which tubercle bacilli may readily find a favorable nidus for implantation and growth.

The results of the earlier investigations by the Metal Polishers' Union are in part confirmed by the statistics of the Metal Polishers,

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[1] The Workers of the Nation, Vol. 1, p. 57.

Buffers, Platers, Brass, and Silver Workers' Union of North America, which, for the 5-year period from 1909 to 1914 include 242 deaths from all causes, of which 31.9 per cent were from tuberculosis. The details of the mortality analysis are as follows:

TABLE 29.—NUMBER AND PER CENT OF DEATHS DUE TO EACH SPECIFIED CAUSE, AMONG METAL POLISHERS, BUFFERS, ETC., 1909 TO 1914

Cause of death.	Number.	Per cent.
Tuberculosis	77	31.9
Pneumonia	31	12.9
Heart disease	31	12.9
Violence (including 6 suicides)	19	7.9
Other preventable causes	20	8.0
Other degenerative diseases	57	23.5
All other causes	7	2.9
Total	242	100.0

Table 29 is derived from the report by Hayhurst on "Industrial Health Hazards," 1915, in connection with which there has been published a quotation from an official letter stating in explanation that—

> You will note from the report the large per cent of our members that die from pulmonary tuberculosis. All of these deaths we believe were contracted by working at this trade, but the sad feature is that at least 95 per cent of those that contract consumption, working at our dangerous trade, will not acknowledge they have the disease until they are too far gone for recovery. They then quit the trade and try to get a position out in the air, often as collectors, driving laundry wagons, on a farm, or, if fortunate enough, go West. These we believe eventually succumb to the disease contracted while working at the trade. We lose all track of them and have no record. If it were possible to keep this record, the percentage of deaths in our trade would be enormous.

In addition to the table, it is said that the median age at death of the 242 metal polishers, buffers, etc., was 40.1 years, while for those who died of tuberculosis it was 37.27 years. Most of the men who enter this trade start work as mere boys, between 16 and 18 years of age, so that the health-injurious consequences are of increased economic significance.

POLISHING PROCESSES IN VARIOUS INDUSTRIES.

The observations by Hayhurst in connection with polishing and buffing are of exceptional value, in that they are based upon an extended personal investigation, including 51 plants, in 11 different cities, employing a total of 846 wage earners. Since the surrounding circumstances of polishers and buffers vary considerably on account of the numerous industries in connection with which such processes are carried on, it may be stated in this connection that among the industries investigated in Ohio were those manufacturing brass and bronze products, electrical apparatus, mirror making, cash registers, stoves and furnaces, foundry and machine shop products, coffin fixtures, cutlery and tools, copper, tin and sheet metal goods, automobiles and parts, jewelry, regalia, scales and balances, sewing machines and parts, scientific instruments, fiber combs, aluminum combs, signs and advertising novelties, etc. It is, therefore, quite clear that the statistical data concerning the mortality of a group of employees classified merely as polishers and buffers, and without reference to the special line of work in connection with which these particular processes are carried on, can not be entirely conclusive. Hayhurst in the report referred to points out that—

> Dust in the breathing atmosphere was a negligible hazard in 12 places, fairly so in 17 more, but was bad in the remaining 22. It consisted chiefly of iron, steel, brass and bronze alloys, other soft metals, glass, etc., which were being worked upon, as well as the components of the polishing wheels (emery, silica, etc.) and of the buffing wheels (cotton and lint fibers, glue substances, etc.). In some places it was kicked up from the floors because of inefficient cleaning, and also dry sweeping during work hours. These dusts are, of course, the most harmful to which workers may be subjected, since they are exceedingly hard, crystalline, and very fine, or irritating, and, in the majority of instances, poisonous. There are so many consumptives in the trade that the infection factor is also added.

VENTILATION AND SANITARY CONDITIONS.

With special reference to ventilation, it is stated that conditions were good in 16 places, fairly so in 17, but the air was close and confined and often contaminated with various fumes and gases from other processes in the remaining 18. Constant standing in a partially stooped posture with very little variation is referred to as an additional hazard in this industry. As regards the special liability to the contraction of communicable diseases, this was considered exceptionally serious in 24 places and considerably so in at least 18 more, "due particularly to promiscuous spitting on dusty floors and the absence of cuspidors." As to the use of protective devices, it is said that, " Occasionally some men were seen who were wearing respirators and endeavoring by this means to filter out the dust from the air which they inhaled."

Aside from the dust hazard, polishers and buffers were found to be subject to a liability to poisoning by lead, potassium cyanide, nitric-acid fumes, phenol, amyl acetate, benzine, alum, crude paraffin, furnace gas fumes, brass fumes, plating fumes, and acid-dipping fumes. The general health appearance of the workers in 24 plants was found to be good, in 13 it was bad, and in 14 more it was only fair. Positive evidence of industrial disease was observed in 8 plants, including 17 cases. Hayhurst concludes that—

As the constant breathing of harmful dust and the continual assuming of unnatural and strained postures are foreign to the physiology of the human organism, it is highly necessary that dust be kept out of the breathing atmosphere and to introduce measures which will vary the work for this class of workers. Unfortunately, it is looked upon as a skilled trade and this makes it difficult to introduce work variations. This does not detract, however, from its hazardous character. The toll of deaths from preventable causes bears this out. It is a process of modern times. One point which particularly impressed our investigators was that where blower systems were installed they were often very inefficient at the time of inspection and were said to be so most of the time. There appears to be but one way of getting around this—to make it somebody's business in each such room to see that such systems are in working order and to provide for compensation for this purpose. A metal or wooden "chest protector" prevents harmful pressure against the person. Other features, the liability to poisoning; etc., require the same precautions as elsewhere. Especially should medical supervision be adopted for this class of workers, as they are at a process which appears to take 20 or 25 years off of their lives.

DUST HAZARDS IN BUFFING.

Some rather interesting additional observations in connection with the special dust hazard of buffing are contained in a descriptive account of the hazards of the tin and copper smith's industry by Charles C. Dominge, of the New York Fire Insurance Exchange (Weekly Underwriter, Nov. 6, 1909), in part as follows:

> The buffing process is the most hazardous of all on account of the liability of spontaneous combustion. A very fine dust or lint is thrown off the buffers in this process. This dust is very hazardous, as the buffing wheels are in many cases saturated with oil used in polishing, and if allowed to fall to the floor, or accumulate in corners where oil or grease may be, it becomes an easy source of spontaneous combustion. In most plants a small blower system empties the dust into a barrel about half full of water located in a metal-lined room. A standard condition would call for a blower system similar to that used in woodworking establishments, only, of course, on a smaller scale. The blowers should lead directly on the outside of building to the roof, discharging their contents into a "cyclone" or separator, whence an outside duct carries the lint to a fireproof vault (with vent) detached at least 5 feet from main risk. Inspectors should satisfy themselves that there are no defects in the system, and should follow same from start to finish.

MORTALITY OF BUFFERS, FINISHERS, AND POLISHERS—MEDICO-ACTUARIAL EXPERIENCE.

The precautions called for by the introduction of adequate measures for the control of the fire hazard are quite certain to react favorably upon the sanitary conditions of the industry. In American life-insurance experience, metal burnishers, buffers, finishers, and polishers, excluding foremen and superintendents, have proven decidedly unfavorable as a class of risks at ages 30 to 59, with an excessive mortality of about 14 per cent. The results of the medico-actuarial investigation with reference to this group of employees are shown in Table 30. The effect of medical selection must be taken into account.

TABLE 30.—MORTALITY FROM ALL CAUSES AMONG METAL BURNISHERS, BUFFERS, FINISHERS, AND POLISHERS, EXCLUDING FOREMEN AND SUPERINTENDENTS, BY AGE GROUPS—MEDICO-ACTUARIAL INVESTIGATION.

Age at death.	Number exposed to risk 1 year.	Actual deaths.	Expected deaths.	Ratio of actual to expected deaths.
15 to 29 years	7,601	28	34.47	81
30 to 39 years	5,500	35	30.78	114
40 to 49 years	1,422	14	12.35	113
50 to 59 years	316	7	6.15	114
60 years and over	35	2	1.27	157
Total, 15 years and over	14,874	86	85.02	101

The available evidence regarding the unhealthfulness of this group of occupations is, therefore, quite conclusive. In view of the relatively large proportion of young persons, both men and women, employed at polishing and buffing, the required sanitary precautions are of special importance. The efforts of the Buffers and Polishers' Union to bring the most trying conditions to public attention are deserving of appreciation. The rigid enforcement of laws enacted to compel factories and workshops where polishing and buffing are being done to install exhaust fans to minimize the dust danger may be laid down as a principle of labor legislation of the first order of importance. Among the dusty trades there are few more typical, on the one hand, of the health-injurious consequences of the continuous inhalation of metallic and mineral dust, and, on the other, of the far-reaching practical possibilities of effective ventilating devices so constructed as to remove the largest possible quantity of dust at the point of origin and of preventing general air pollution to the largest attainable degree.

MORTALITY OF POLISHERS—INDUSTRIAL INSURANCE EXPERIENCE.

The most conclusive mortality statistics concerning polishers are the industrial insurance experience data of the Prudential Insurance Co. of America for the period 1897 to 1914, including 964 deaths from all causes, of which 355, or 36.8 per cent, were from pulmonary tuberculosis.

TABLE 31.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG POLISHERS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, COMPARED WITH THAT OF ALL MALES IN UNITED STATES REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of polishers, 1897 to 1914, from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Polishers.	Males in registration area, 1900 to 1913.
15 to 24 years	136	59	43.4	27.0
25 to 34 years	230	129	56.1	30.5
35 to 44 years	241	106	44.0	23.4
45 to 54 years	173	43	24.9	14.7
55 to 64 years	112	16	14.3	7.9
65 years and over	72	2	2.8	2.6
Total, 15 years and over	964	355	36.8	13.9

According to Table 31, the proportionate mortality of polishers from pulmonary tuberculosis is relatively excessive at all ages, but particularly so at ages 25 to 34, at which 56.1 per cent of the deaths of polishers from all causes are from pulmonary tuberculosis, against an expected proportion of 30.5 per cent. The excess in the proportionate mortality is, however, significant and suggestive at all ages, and sufficiently so to warrant the final conclusion that the mortality from pulmonary tuberculosis in this occupation must be considered as decidedly above the normal for the general population, although somewhat below the corresponding average for grinders.

CARD GRINDING.

The so-called "carding" of the cotton in the manufacture of cotton textiles is an exceedingly important process. Good carding depends upon good grinding, for if the grinding is not done to perfection, the setting of the cards can not be done with anything like accuracy. The surface of the grinding rollers is usually covered with emery-filleting, and the grinding itself is principally done by the large grains of emery with which the outer surface of the roller is covered. There is, therefore, a mixed exposure of metallic and vegetable fiber dust, particularly in the cleaning process, since, when the grinding is considered sufficient or "finished," the cards must be well brushed to clear away the dust, etc. The object of carding is to "disentangle the fibers of cotton and lay them lengthwise and parallel with each other." This process necessarily results in the production of a considerable amount of fine fluff, of vegetable fiber origin, intermixed with the metallic dust resulting from the use of emery substances. The quantity of emery dust generated in this process is, however, apparently not very serious, and more importance is attached to the cotton-fiber dust which must necessarily tend to increase the health-injurious nature of this, as well as all other employments in the carding room. Whether there is any essential difference in the health and mortality of card grinders as differentiated from carders is difficult to determine in the absence of trustworthy statistical information.

Such observations as have been made regarding the personal physical appearance of employees in connection with this process have been suggestive of health-injurious results. The total number of persons reported as being employed at card grinding during the census year was only 1,091, of which 1,087 were males and 4 females. On account of the small number reported employed, the age returns can not be considered conclusive. Card grinding, apparently, is quite often carried on in connection with other employments in the carding room, and this is especially true of small cotton mills.

FILE CUTTING.

The specific effect of this occupation on health and longevity is medically recognized in the term "file-cutters' disease," which is a form of pneumoconiosis. The occupation is rarely carried on entirely by itself, and there are no trustworthy data regarding even the approximate number of men employed in this industry. The making of rasps and files is generally carried on in connection with other branches of the toolmaking industry. An important center of manufacture is the city of Newark, N. J., but no conclusive data regarding the mortality of men employed in this occupation have been made available through local vital statistics. How far file cutters require to be differentiated from file grinders is not ascertainable at the present time.

VARIATIONS IN OCCUPATIONAL EXPOSURE.

Much of the modern work is done on wet grindstones, by means of which the dust hazard has been materially reduced. Workers on dry emery wheels are, of course, excessively exposed to a mixed dust hazard of metallic and mineral origin. Aside from the dust hazard, there is a liability to lead poisoning in connection with the hardening process. By some authorities the hardening process is considered more injurious than the dust exposure. The occupation is briefly discussed in the Report of the Massachusetts State Board of Health upon the Sanitary Condition of Factories, etc., 1907, in part, as follows:

> In the manufacture of files the workmen are exposed to a double danger, namely, exposure to metallic dusts and contact with metallic lead. The best files are cut by hand, no machine having as yet been invented which can produce their equal. The blanks are first

ground smooth with the aid of stones, and in this operation considerable mineral and steel dust is caused. During the process of cutting the file lies on a base of lead and the lines are cut by a chisel struck by a heavy hammer. The leaden bed offers sufficient resistance, while at the same time it is sufficiently yielding to prevent a sharp recoil. As the file is cut it is constantly brushed off, usually with the hand, which thereby becomes to a certain extent coated with very fine particles of lead, and the air becomes more or less impregnated with lead and steel dust. A common habit of file cutters in manipulating the file is to wet the finger and thumb with the tongue, thus conveying to the mouth particles of lead, which, through the acts of conscious and involuntary swallowing, gain access to the stomach. The work is very laborious, and the attitude which the workmen are obliged to assume is one which does not admit of normal respiratory movements, since they sit at a bench and stoop over the file. The workmen of this class are notoriously careless, and are inclined to reject the idea that their calling is not free from danger; but, although in the establishments visited an occasional workman was observed to be pale and sickly in appearance, it must be admitted that as a class they looked well and strong. Five shops of this class, employing from 5 to 70 persons (150 in all), presented reasonably good hygienic conditions. All showed fairly good ventilation, and but two were not well lighted. In two, employing, respectively, 8 and 60 workmen, considerable dust was perceptible in the air.

In 1903 the British Government published a report on the proposed draft regulations relating to the process of file-cutting by hand, which among other observations includes the statement that—

> The trade of file cutting by hand is one that may be distinctly classed as dangerous and certainly in need of regulation; in addition to this, in Sheffield at all events, the trade is, generally speaking, carried on under most insanitary conditions. The principal danger to the worker arises from the handling of the lead bed on which the file is cut, and from inhaling the lead dust produced by the blows of the hammer in cutting the files, and in brushing the files when cut. * * * It seems to be the better opinion that the danger arising from the handling of the lead bed was greater than that from the inhalation of the dust. As the result of using the lead bed the file cutter by hand is peculiarly liable to plumbism and to nervous and urinary diseases. Phthisis is also a disease to which the file cutter is subject considerably in excess of workers in most other trades; this seems to be due to the insanitary conditions under which he works acting on a system already enfeebled by the mischief of the lead. * * * The expression "file maker" includes file cutters by machinery as well as file cutters by hand. Now, as file cutting by machinery does not involve the use of the lead bed and is not carried on under the insanitary conditions prevailing in file cutting by hand, file cutting by machinery can not be said to be a dangerous trade. It is therefore obvious that the mischief amongst file cutters by hand is greater than that given by the tables as occurring amongst file cutters as a whole.

The subject has also been discussed in the Third and Fourth Interim Reports of the Dangerous Trades Committee of the British Home Office, 1898–99. In the absence of strictly conclusive mortality data with a due regard to ages at death and the causes thereof, the available information must be considered rather inconclusive.

DESCRIPTIVE ACCOUNT OF SANITARY CONDITIONS IN OHIO.

Hayhurst has reported, for Ohio, the results of an investigation of four establishments employing 108 male wage earners, including some machine file cutting in two establishments. It is stated that there were no special devices which could be designated as health appliances in any of the plants, even the forges in a large plant being without hoods and vents. According to this investigation—

> Dust was a hazard to grinders in all places, although the principal work was done in the wet on large grindstones. The friction heat present, however, with the flying of sparks, caused a certain amount of fine dust to escape, in spite of the water. There were a number of unprotected emery wheels. Polishing was also done by sand blasts. A small but constant amount of dust was also produced during cutting which always contained some lead scraped loose from the "bed" which supported the file. Workers' faces were also quite close to the work. None of the places visited was exemplary in matters of cleanliness and order, while in three there was plenty of dirt and waste accumulations. A dirt floor was present in one place located in basement-like quarters. Dampness was a feature of the work in the grinding rooms, where the water occasionally escaped from the grindstones and soaked up the floors. The lighting of the quarters was good in two places and poor in the other two, in one of which oil lamps were depended upon for the principal illumination. The general ventilation of quarters was fair to good. The ceilings in one place were scarcely 7 feet high. Contamination existed from heating ovens, forge gases, tempering pots, and annealing furnaces, and from crude heating arrangements in two places. The question of fatigue is not debatable, at least for the skilled workers. There is an unusual amount of reduplication of the same movements and monotony in the hand cutting process (from continuous mallet and chisel work) and also in grinding, with the assumption of awkward, stooped postures in both processes and pressure against the body. It is estimated that the cutter strikes 45,000 blows a day in turning out his quota of files. In one plant practically all work was piecework, while noise was excessive from trip hammers. The workday was 9 hours in the smallest place and 10 hours in the other three, with one-half hour for a noon recess. The liability to the contraction of communicable diseases was considerable in all places, due to the use of common drinking cups, promiscuous spitting upon the floors, and in dust and dirt accumulations, the absence of washing facilities in two places, poor toilet arrangements, and the presence of dust and dirt from the processes. The liability to industrial poisoning was considerable for the hand cutters where soft lead plates were used beneath the files worked upon, due to the creation of a fine dust and to the lack of personal care in keeping the soiled fingers away

from the lips. Again, in the lead tempering process (part of the tempering was done by heating in charcoal and coke and then immersing in brine), there were the same hazards as described under this process elsewhere. Chronic or slow lead poisoning is the form of the disease most likely to be present, although the personal factor of carelessness might produce acute poisoning in a short space of time.

In addition to the foregoing observations it is pointed out that special emphasis was placed upon the risk of lead poisoning, and that in some places there appeared to be an unnecessary exposure to dust from grinding processes which apparently could have been easily equipped with a blower system. Reference is also made to a statement by Sir Thomas Oliver that—

> The death rate of the cutters from pulmonary phthisis and lead poisoning exceeds the mortality standard of ordinary occupied males by 90 per cent, and after 35 years of age it is still higher.

FILE CUTTING BY HAND AND BY MACHINERY.

The conclusion advanced in the report on the draft regulations concerning the process of file cutting by hand, that file cutting by machinery removes part of the hazard, is sustained by the Ohio investigation. That the risk has elsewhere been recognized is brought out by the fact that the German Imperial Board of Health has issued a special circular concerning health precautions to file makers, the text of which, however, has not been available for the present purpose.

W. Gilman Thompson refers to the industry in his treatise on "The Occupational Diseases," in part, as follows:

> In cutting the ribs of files the articles are imbedded in a block of lead, which offers the proper degree of resistance or rebound when the cutting chisel is struck by the hammer. Much lead dust, besides iron filings, is thus produced, and the workmen have the habit of moistening the fingers in the mouth to obtain a firmer grasp upon the cutting instrument. Thus they both swallow and inhale much lead dust. Wooden or tin blocks may be used to replace the lead, but are less satisfactory. The increasing use of file-making machinery is doing much to lessen the frequent cases of lead poisoning which characterize this trade, but as the machines strike from 400 to 1,000 blows a minute they raise considerable lead dust.

LEAD POISONING.

Thompson quotes White to the effect that "out of 100 English file cutters examined by him 74 exhibited the results of lead poisoning, while the mortality of the trade was found to be excessive. Leaning over the work and raising the lead dust by hammering constitute the special risk, apparently." Thompson also quotes Sprenger, according to whom "among 93 file makers examined in Berlin more than 5 per cent were afflicted with lead poisoning after having been at work a little more than two years."

Apparently the risk of lead poisoning is more serious than the inhalation of metallic and mineral dust; but, as said before, accurate and conclusive data concerning this occupation are not at present available. The only statistical reference of value occurs in the Supplement to the Sixty-fifth Annual Report of the Registrar General of Births, Deaths, and Marriages in England and Wales, in part, as follows:

> File makers experience more than twice the average mortality from nervous diseases and nearly four times the average from Bright's disease, but cutlers experience comparatively little excess of mortality from either of these causes. In both industries the mortality from phthisis is enormous, the figure for cutlers being nearly three times and that for file makers more than twice the standard, and in both occupations the mortality from respiratory diseases approaches double the standard. Both these workers, however, experience a low mortality from influenza, from alcoholism and liver disease, and from accident, while among file makers the mortality from cancer is also less than normal.

GENERAL CONCLUSIONS.

This statement sustains the earlier conclusion that this occupation is not readily separated from other employments, chiefly the manufacture of cutlery and tools, with which it has much in common. The general conclusion is that the employment is one involving serious dust hazards demanding more qualified medical and administrative consideration.

TOOL AND INSTRUMENT MAKERS.

The manufacture of tools and instruments includes a large number of grinders and polishers, but it is not possible to classify the occupations in detail. In the United States census statistics the industry includes cutlery manufacture, while in English mortality statistics the group comprehends tool, file, and saw makers, cutlers and scissors makers, and needle and pin makers. The statistics of 1910 for the United States return 20,212 males of known ages, 10 years or over, employed in this industry as previously defined, and of this number 3,669, or 18.2 per cent, were 45 years of age or over. The proportion attaining to old age was, therefore, somewhat larger than expected, considering the high rate of mortality of grinders and polishers, and others employed in the manufacture of tools, instruments, etc.

SANITARY CONDITIONS OF EMPLOYMENT IN MASSACHUSETTS.

A special investigation into the sanitary conditions of this employment was made by the Massachusetts State Board of Health in 1907, and the report included a number of very valuable and suggestive references to conditions unfavorable to health and life, from which the following extracts are made:

From a sanitary point of view, the one important part of this industry is the reduction of the surface of the article in process of manufacture from the roughness of the original casting to the smoothness and brilliancy so necessary and desirable in the finished product. This involves successive treatment by wet grinding, dry grinding on emery and corundum wheels, and polishing with rouge on buffing wheels. Each of these processes, even that of wet grinding on large, coarse, and finer stones, causes to be cast into the air large amounts of fine dust, made up of very fine particles of steel and of the abrasive substance. In establishments properly equipped and conducted, provision is made to reduce the danger of this dust to a minimum by means of hoods connected with a system of exhaust fans or blowers. In spite of the precautions taken to protect their health, a very large proportion of grinders recklessly remove the hoods, and thus expose themselves unnecessarily to this especially dangerous form of dust. They assert that they prefer freedom of movement with dust to the protection afforded by hoods.

The workmen are not, as a class, long lived; indeed, the nature of the work is not compatible with longevity, and a person entering upon it in middle life is unlikely to follow it many years. Whatever the age at which the trade is taken up, a man in sound health who has followed it a few years is an acknowledged rarity. A study of the death returns of the city of Northampton, which is one of the centers of this industry, for the past 12 years, yields facts which can be interpreted in only one way. During this period tuberculosis is given as the cause of death in no less than 54.5 per cent of those whose occupation is indicated by "grinder" or "polisher," and in 45.4 per cent of those designated generally as "cutlers," and of the latter 36.4 per cent died of pneumonia. Taken together, the "grinders," "polishers," and "cutlers" returns show that, during this period, diseases of the lungs were responsible for 72.73 per cent of their mortality. As was shown in the preliminary report on this industry, the tuberculosis death rate for cutlers in Northampton is four times as high as that for the entire adult male population.

DIFFICULTIES IN EFFECTIVE VENTILATION.

A difficult problem in the cutlery and tool industry is how to secure effective ventilation, and many of the factories and workshops inspected were found to be seriously defective in this respect. A large proportion of the workmen, including many young boys, are exposed to considerable dust, chiefly, of course, in the grinding and polishing departments. While much has been done to improve the sanitary conditions by artificial ventilation, there has been but a very indifferent cooperation on the part of the operatives themselves, and many in fact are interfering with the arrangements made for their protection to the extent of removing the hoods and exhaust pipes installed for the purpose of carrying off the dust.

VITAL STATISTICS OF ENGLISH TOOL AND CUTLERY MAKERS.

The most valuable official statistics are those for England and Wales, published at decennial intervals in the supplements to the reports of the registrar general of births, deaths, and marriages. Only two comparatively recent investigations are here referred to. The first of these, for the three years ending with 1892, included 2,529 deaths from all causes, of which 505, or 20 per cent, were from pulmonary tuberculosis. Of diseases of the respiratory system other than pulmonary tuberculosis, 384 deaths were from bronchitis, 286 from pneumonia, and 78 from other diseases of this group, a total of 748, or 29.6 per cent, of the mortality from all causes. Combining the mortality from pulmonary tuberculosis and other respiratory diseases, it is found that 49.5 per cent of the deaths of tool and instrument makers, as previously defined, were from diseases of the lungs and air passages.

The most recent English mortality statistics of tool and cutlery manufacture are for the three years ending with 1902, referred to in the Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales, in part as follows:

> In the occupation as a whole the mortality at ages under 25 is below the standard for occupied and retired males; but among file makers the death rate at these ages exceeds the standard. Beyond age 25 the mortality in the whole occupation, as well as among cutlers and file makers, considerably exceeds the standard. At ages 45 to 65 years the death rate among cutlers is 72 per cent and that of file makers is 84 per cent above the average. Within the main working period of life the comparative mortality figure for the whole occupation is 1,315, or 31 per cent, above the standard. The mortality from lead poisoning is nine times and that from phthisis is nearly double the standard, and these workers suffer excessively from nervous, circulatory, respiratory, and urinary diseases. On the other hand, the mortality from alcoholism and liver disease and from accident is about half the average. Among cutlers and file makers the comparative mortality figures considerably exceed the average for the entire occupation, the figure for the former being 56 per cent above the standard for all occupied and retired males, while that for the latter is 69 per cent in excess. Indeed, these two occupations appear to be the most unhealthy in the whole group of workers in metal. It should be mentioned in this place that the occupation of file maker is one that is specially liable to lead poisoning, the mortality figure for plumbism being no less than 56, whilst among all occupied and retired males the mortality is represented by unity.

File makers experience more than twice the average mortality from nervous diseases and nearly four times the average from Bright's disease, but cutlers experience comparatively little excess of mortality from either of these causes. In both industries the mortality from phthisis is enormous, the figure for cutlers being nearly three times and that for file makers more than twice the standard, and in both occupations the mortality from respiratory diseases approaches double the standard. Both these classes of workers, however, experience a low mortality from influenza, from alcoholism and liver disease, and from accident, while among file makers the mortality from cancer is also less than normal.[1]

MORTALITY FORM PULMONARY TUBERCULOSIS AND NONTUBERCULOUS RESPIRATORY DISEASES.

The English occupation mortality statistics for men employed at tool, instrument, and cutlery making are quite conclusive of the more or less unfavorable effects of this industry on health. In Table 32 a comparison is made of the mortality from all causes among men in this group with occupied males generally, and the result is decidedly suggestive of conditions in this trade more or less unfavorable to life and health, but in particular at ages 45 or over, when the general mortality of this class exceeds the general average by from 8.24 to 12.26 per 1,000.

TABLE 32.—MORTALITY FROM ALL CAUSES AMONG TOOL, INSTRUMENT, AND CUTLERY MAKERS, COMPARED WITH THAT OF ALL OCCUPIED MALES, IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[Source: Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 for all occupied males.	Death rate for tool, instrument, and cutlery makers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Per cent of rate for all occupied males.
15 to 19 years	2.44	2.09	− 0.35	86
20 to 24 years	4.41	3.32	− 1.09	75
25 to 34 years	6.01	6.32	+ .31	105
35 to 44 years	10.22	13.65	+ 3.43	134
45 to 54 years	17.73	25.97	+ 8.24	146
55 to 64 years	31.01	42.05	+11.04	136
65 years and over	88.39	100.65	+12.26	114

The preceding table is self-explanatory. A more extended comparison, however, is made in Table 33, in which the mortality of tool, instrument, and cutlery makers from pulmonary tuberculosis and other respiratory diseases is compared with the normal mortality of occupied males from these diseases by divisional periods of life. The comparison shows that at ages 25 and over the mortality from pulmonary tuberculosis is excessive among tool, instrument, and cutlery makers, and decidedly so at ages 35 to 64, inclusive. The table further shows that the mortality from other respiratory diseases is excessive among men in this class, but decidedly so at ages 45 or over, reaching the highest rate at ages 65 and over, when the excess is 7.69 per 1,000. The two tables, derived from English experience, fully confirm the previous conclusion that the mortality of tool, instrument, and cutlery makers is excessive when comparison is made with the normal mortality of occupied males generally, and that this excess is largely because of a high degree of frequency of pulmonary tuberculosis, particularly at ages 25 to 64, when the excess is from 0.91 to 4.09 per 1,000.

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[1] Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales, pp. lxix, lxx.

TABLE 33.—MORTALITY FROM PULMONARY TUBERCULOSIS AND FROM OTHER DISEASES OF THE RESPIRATORY SYSTEM AMONG TOOL, INSTRUMENT, AND CUTLERY MAKERS, COMPARED WITH THAT OF ALL OCCUPIED MALES, IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[Source: Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Mortality from pulmonary tuberculosis.				Mortality from other diseases of the respiratory system.			
	Death rate per 1,000 for all occupied males.	Death rate for tool, instrument, and cutlery makers.			Death rate per 1,000 for all occupied males.	Death rate for tool, instrument, and cutlery makers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Per cent of rate for all occupied males.		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Per cent of rate for all occupied males.
15 to 19 years.....	0.54	0.17	−0.37	31	0.24	0.23	−0.01	96
20 to 24 years.....	1.55	1.57	+ .02	101	.48	.56	+ .08	117
25 to 34 years.....	2.03	2.94	+ .91	145	.77	1.14	+ .37	148
35 to 44 years.....	2.74	5.90	+3.16	215	1.66	2.01	+ .35	121
45 to 54 years.....	3.04	7.13	+4.09	235	3.32	5.40	+2.08	163
55 to 64 years.....	2.16	5.26	+3.10	244	6.54	10.42	+3.88	159
65 years and over.	1.11	1.97	+ .86	177	17.77	25.46	+7.69	143

MORTALITY OF TOOL AND CUTLERY MAKERS—UNITED STATES REGISTRATION AREA.

The mortality of American tool and cutlery makers has been reported upon by the Division of Vital Statistics of the United States Census Bureau only for the year 1909, and no subsequent information has been made public, so that the data are of rather limited value. According to the census report, out of 241 deaths of tool and cutlery makers from all causes, 58, or 24.1 per cent, were from pulmonary tuberculosis, which compares with 17.8 per cent for jewelers and 29.5 per cent for printers, lithographers, and pressmen. On account of the rather peculiar age distribution the general average, however, for all ages can not be safely utilized for comparative purposes. The details of the mortality of tool and cutlery makers by divisional periods of life are shown in Tables 34 and 35.

TABLE 34.—PROPORTIONATE MORTALITY OF TOOL AND CUTLERY MAKERS FROM PULMONARY TUBERCULOSIS, UNITED STATES REGISTRATION AREA, 1909, BY AGE GROUPS.

Age at death.	Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent of deaths from all causes.
15 to 24 years	22	4	18.2
25 to 34 years	37	15	40.5
35 to 44 years	45	19	42.2
45 to 54 years	38	10	26.3
55 to 64 years	42	8	19.0
65 years and over	56	2	3.6
Age unknown	1	......	......
Total, 15 years and over	241	58	24.1

TABLE 35.—PROPORTIONATE MORTALITY OF TOOL AND CUTLERY MAKERS FROM NONTUBERCULOUS RESPIRATORY DISEASES, UNITED STATES REGISTRATION AREA, 1909.

Cause of death.	Deaths from nontuberculous respiratory diseases.	
	Number.	Per cent of deaths from all causes.
Asthma	......	......
Bronchitis	3	1.2
Pneumonia	23	9.6
Other nontuberculous respiratory diseases	3	1.2
Total	29	12.0

Table 34 emphasizes a decidedly excessive proportionate mortality from pulmonary tuberculosis among tool and cutlery makers at ages 25 to 64, inclusive. There is also, as shown in Table 35, a relatively high proportionate mortality from nontuberculous respiratory diseases, equivalent to 12 per cent of the mortality from all causes, chiefly attributable to pneumonia. The proportion of deaths from pneumonia is 9.6 per cent of the deaths from all causes, which compares with 5.8 per cent for jewelers and 6.8 per cent for printers, lithographers, and pressmen, according to the data derived from the same official American sources.

MORTALITY OF TOOL AND INSTRUMENT MAKERS—INDUSTRIAL INSURANCE EXPERIENCE.

The only other available mortality data of tool and instrument makers are derived from the industrial insurance experience of the Prudential Insurance Co. of America for the period 1897 to 1914, including 533 deaths from all causes, of which 170, or 31.9 per cent, were from pulmonary tuberculosis. Table 36 is not, however, strictly comparable with Table 34 on account of probably important differences in the classification of the occupations considered.

TABLE 36.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG TOOL AND INSTRUMENT MAKERS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, COMPARED WITH THAT OF ALL MALES IN UNITED STATES REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of tool and instrument makers, 1897 to 1914, from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Tool and instrument makers.	Males in registration area, 1900 to 1913.
15 to 24 years	88	33	37.5	27.0
25 to 34 years	93	49	52.7	30.5
35 to 44 years	111	41	36.9	23.4
45 to 54 years	98	33	33.7	14.7
55 to 64 years	67	7	10.4	7.9
65 years and over	76	7	9.2	2.6
Total, 15 years and over	533	170	31.9	13.9

According to this table the proportionate mortality from pulmonary tuberculosis is excessive at every divisional period of life, but particularly so at ages 25 to 34, at which, of the mortality from all causes, 52.7 per cent is from pulmonary tuberculosis. The data for this group of occupations are not, of course, entirely conclusive, in that the group considered includes a number of special employments of a varying degree of metallic-dust exposure. Since tool and instrument manufacturing is frequently combined with the cutlery and related trades the latter must be taken into account for comparative purposes. In all of these trades grinding, polishing, and buffing are incidental operations, and, though elsewhere separately considered, these are practically inclusive of the entire group of tool and instrument-making and the cutlery industries.

GENERAL CONCLUSIONS.

With a due regard to these rather serious limitations it is safe to conclude that, considered as a group, the manufacture of tools and instruments must be considered as one of the distinctly unhealthful trades, and primarily so on account of continuous and considerable exposure to the inhalation of metallic dust.

SAND BLASTING.

This is a rather obscure occupation, regarding which the literature is of very limited extent. The census of 1910 returns only 101 persons employed as sand blasters in connection with the iron and steel industry, but in all probability the number so employed is much larger.

There are no occupation mortality data regarding this employment, which, from a hygienic point of view, is of considerable importance.

DESCRIPTIVE ACCOUNT OF SAND-BLASTING PROCESSES.

The most useful discussion of this occupation occurs in Hayhurst's Ohio Survey of Health Hazards, as follows:

Sand blasting is a process in which fine sand or similar hard substance is forced through a pipe by compressed air against objects either for the purpose of cleaning their surfaces or of giving them an etched, frosted, or rough effect. Hence the process is used upon a considerable variety of materials. As it is very rapid, usually only a few workers are so employed even in very large establishments. Our investigations covered the process in 9 different industries, viz, automobiles, cars, carriages, electrical apparatus, brass, iron, glass, cutlery and tools, and machine manufacture. There were 51 wage earners, all males, found so employed. For some work considerable skill is necessary, but in the majority of instances it is a process for unskilled labor. Retention at the process was good in 3 places, fair in 3, and very brief in the remaining 3. Health appliances, consisting of isolation of the process in a room by itself and within a cupboard through which the worker inserted his hands, or the wearing of a helmet covering the entire head—these features were found good in 3 places, fair in 3, and practically absent in the remaining 3. Instructions to limit the dust in order to conserve the health of the worker were good in 5 places, but very little attention was paid to the same in the remaining 4. In but 1 place did the workers enjoy the privilege of a sick-benefit association. The work was done in the same quarters with other processes in 3 instances, so that other workers were exposed to the fine dust created. Of all the employees, 13 were over 40 years of age and 38 under 40.

DUST AND OTHER HEALTH HAZARDS.

Dust in the breathing atmosphere was a negligible factor in 2 places, a fair hazard in 4, and bad in 3. Cleanliness of quarters took about the same proportions. Dampness was no feature of the process, nor were harmful light effects. Heat, due to the proximity to other processes as a rule, was bad in 1 place, fair in 2 more, and no feature in the remaining 6. Cold weather, due to performing the work, protected only by a roof, was a feature in 2 places. Fatigue was not a special hazard, although hurrying piecework, monotony, and constant standing were features in one-third of the places. The workday was from 9 to 10 hours in all places. The noon recess was 1 hour in 1 place, three-quarters of an hour in 3, and one-half hour in 5 places. The liability to the contracting of communicable diseases was negligible in 3 places, a fair risk in 5, and bad in 1, due, principally, to the breathing of fine dust in quarters where there was promiscuous spitting, absence of cuspidors, inadequate washing facilities and improper closets, and the failure to inquire into the fitness of the workers for such work. Poisoning was no feature. The general factors favoring stimulantism were the irritating effects of fine dust inhaled and swallowed and the absence of good drinking-water facilities in some places. The health appearance of the workers was not good in one-third of the places. The workers' complaints were the breathing of dust, skin irritation in hot weather, and the inefficiency of some of the hoods used, while in 1 place the manager said they were having it done at night because it made so much dust. *Comments.*—Such work should be done in a manner to keep the dust away from the employee, such as confining the process within an impervious cupboard, through which armholes are made, or having it done in a dust-tight room in which the worker should be supplied with an impervious suit and helmet, to which is attached an air tube supplying him with fresh outdoor air under pressure. The simple wearing of respirators, even of helmets, without such air tubes is not at all efficient, as can be demonstrated by noting the amount of fine dust settled upon the workmen's features when such coverings are removed. Many places substitute sand blasting by cleaning small pieces in a rattler.

The occupation was inquired into by the New York State Factory Investigating Commission and briefly referred to in its second report (Vol. II, pp. 420 and 479, 1913). It is said that—

> Sand blasting is still done in closed bins or basements by ancient and crude methods, without any other protection to the workers than a cloth over the mouth and nose. The fumes from pouring molds are allowed to disseminate in the air of shops, fume vents being found in but few plants. Temperatures are often very high, especially near the furnaces.

With special reference to the use of respirators in connection with this process, it is stated that—

> Neither in sand blasting nor in lead works nor in any other occupation where the presence of poisonous gases and excessive amounts of dust vitiate the air have respirators been uniformly used. The managers and owners resort to the same plea, viz, the ignorance of the worker and his willful abandonment and neglect of these protective appliances. Few of these managers provide their employees with them, and still fewer make their use compulsory.

A brief descriptive account of the process of sand blasting in connection with castings, in open sheds, is given by Hanson, in his "Dangers to workers from dusts and fumes, and methods of protection," in Bulletin 127, published by the United States Bureau of Labor Statistics. "It is observed in connection with the process that men who do the work are not properly protected, since the helmet does not prevent the inhalation of very fine steel, iron, or brass dust."

With reference to sand blasting castings in closed rooms, an "improved helmet" is described, but even this appliance is considered an inadequate protection.

MOST DANGEROUS OF ALL MINERAL-DUST HAZARDS.

The most recent and thoroughly well-considered observations concerning sand blasting are by W. Gilman Thompson, and on account of their importance they are quoted in full from his treatise on "The Occupational Diseases":

> The sand blast is an apparatus constructed to blow a stream of sand by means of compressed air with great force against metal castings, to clean them from the earth which adheres from the casting molds and to smooth roughened surfaces. It is also employed in cleaning stone and marble buildings and for the roughening of the surface of glass to make "ground glass" and sometimes to mark patterns upon glass, which is partially protected. Sand blasting constitutes probably the most dangerous of all the mineral-dust hazards, and it is impossible to engage in the work without protection of the eyes and face, for the sharp particles of fine silicious sand are driven with such force against the objects operated upon that they rebound toward the workman, and, despite the use of long hose to conduct the blast away from the operator, the surrounding air is constantly filled with flying sand, resembling a sandstorm in the desert. The helmets in use for sand blasting can not have glass windows, but fine wire netting shields the eyes, and cloths are inserted to breathe through.
>
> An important method of reducing the risk of dust from the sand blasting of metal castings is covered by a recent patent of C. Wedemeyer, of Hamburg. The operator stands in a cabinet directing the sand blast away from himself toward the casting. Over his head, at an angle of 45°, a strong blower fan directs a stream of air also upon the casting with such force that the dust of both sand and metal is blown downward toward the opening of a large exhaust tube just above the floor. In this manner a strong, continuous draft blows the dust away from the operator and out of the cabinet through the aspirator duct, which is connected with a powerful exhaust fan.

The descriptive illustration by Thompson, in addition to the photographic reproductions of sand-blasting processes by Hanson, in Bulletin 127 of the United States Bureau of Labor Statistics, previously referred to, emphasize the necessity for thoroughly effective safety precautions, more or less in conformity to the German method, under which the operator is inclosed in a room or cabinet in which he directs the blast of sand and compressed air against the casting in front while a strong air current is forced from directly above his head by a fan and passes outward toward a revolving, aspirating drum on the right. The illustration used by Thompson is from Rauch und Staub (ii, Feb. 5, 1912).

COMBINED METALLIC AND MINERAL DUST EXPOSURE.

The preceding statements suggest the existence of more or less health-injurious conditions, the control of which at present appears to receive inadequate technical consideration. Conditions, of course, must vary according to the quality and degree of fineness of the sand used. In the handling of sand in glass factories serious respiratory difficulties have been experienced in much the same manner as in sand-blasting operations, though apparently to a lesser degree. The occupation, though of rather limited extent, is obviously one which demands more qualified technical consideration regarding its hygienic aspects and the probably quite needless waste of life and health. Of course in the actual operation of sand blasting there results a mixture of metallic and mineral particles, of which the former are distinctly more injurious to health than the latter. It is for this reason that the occupation has been included among employments where the chief exposure is to metallic dust. As measured by the quantity of dust exposure, however, sand blasting more properly belongs to the group of employments with exposure to mineral dust. Thompson for these reasons includes sand blasting under occupations where the chief exposure is to mineral dust.

PROTECTIVE, SAFETY, AND SANITARY DEVICES.

The most recent discussion of sand blasting with special reference to safety and sanitary considerations is by Joseph Brinker, in the Scientific American for September 2, 1916, who describes in some detail the work of the operator in one room while the blast is carried on in another, and under conditions which practically exclude the dust hazard or at least the major portion of the same. It is explained at the outset that the preparing of metal surfaces for a covering of paint has given rise to the extensive use of the sand blast, especially in connection with the manufacture of automobiles. It is said that—

> When the outfits are constructed of sufficient size to accommodate large surfaces such as mud guards, hoods, and bodies, the problem of protecting the workmen has presented serious difficulties.

After explaining that various forms of safety devices for the protection of the operator during the sand blasting have been tried, including the common respirator with a sponge through which the operator breathes, though often under serious difficulties, and various forms of helmets similar to the one used in diving, in which fresh air is supplied under pressure, it is pointed out that—

> The first renders it difficult to breathe; the second type is often so cumbersome that it is discarded by the workmen at their own peril. In fact the history of the use of safety sand-blast devices has proven conclusively that when these may be used or detached at will by the workmen, they are usually discarded, even if such neglect constitutes positive danger.

This difficulty has apparently been overcome in the apparatus described by Brinker which makes it necessary for the operator to use the safety helmet if he is to work at all. A brief explanation of the new method is as follows:

Each sand-blast room is a small compartment of the double-hopper type in which the heavy particles of the sand used in the cleaning process are drawn out of the lower hopper and the lighter particles out of the upper by air suction. The material to be cleaned is laid on a grating between the two hoppers. It is introduced into the compartment through a door at one end. The sand-blast operator's headdress, which is of canvas with a fine-mesh copper screen at the front, is securely attached to the inside of a curtain which forms the front wall of the compartment. This curtain is fastened to sliding metal doors which can be moved horizontally from side to side. In this way it is impossible for the operator to see into the interior of the compartment until he puts his head in the helmet. This being accomplished, he stands on the floor outside the compartment, moving along as is necessary in the progress of his work by pushing the sliding metal doors to either side with his elbows.[1]

GOLD-LEAF MANUFACTURE.

The work of the gold-leaf beater is nearly all handwork, except in the operation of the rolling machines. The trade is carried on to-day in about the same manner as in ancient times. The weight of the hammer used averages 18 pounds, which is more than that of the hammer used by the average blacksmith. Girls, as a rule, are employed in connection with the less arduous operations and the final packing of the gold leaves in boxes and packages. The tissue used in connection with this process is coated with red chalk, the dust of which, of course, enters into the atmosphere of the rooms, usually badly ventilated. One of the chief difficulties in connection with the ventilation is the fact that the slightest draft of air will carry the scrap of gold leaf from one anvil to another and make packing operations difficult or impossible. Evidence that the fine particles of gold enter the atmosphere is found in the fact that workmen with beards turn in less waste gold than clean-shaven workmen, and they are now required to wash before leaving the shop, the water being filtered for the recovery of the metal contained therein.

EARLY OCCUPATIONAL-DISEASE OBSERVATIONS.

Thackrah, writing in 1832, held that goldbeating must be considered a distinct employment, aside from the metal trade generally. Goldbeaters are about half the day engaged in beating the metal with heavy hammers and the rest in spreading the gold leaf on paper. By this change in employment the process affords an excellent alternation of labor and comparative rest. In his opinion the men were not exposed to health-injurious conditions and were generally healthy and robust.[1] It is difficult, however, to accept these conclusions in their entirety. The work of the goldbeater is carried on in rooms the air of which is more or less contaminated and where provision for proper ventilation is extremely difficult if not impossible. The work is often commenced at rather early ages and, in Europe at least, quite a considerable proportion of young persons are employed. Whether gold dust is itself injurious has never been scientifically determined, but it is quite probable that it is less injurious than other metallic dust.

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[1] Of much practical importance is a descriptive account of the dustless Hoevel self-contained sandblast automatic machine and a description in detail of a novel sandblast room, in Safety, published by the American Museum of Safety for January, 1918.

DESCRIPTIVE ACCOUNT OF MANUFACTURING PROCESSES.

The number of goldbeaters in the United States is small, only 607 male and 76 female workers having been enumerated in 1910. An interesting account of the process of manufacture, by Edward Williston Trentz, is as follows:

> The goldbeater receives his material in the form of a ribbon about an inch wide and 24 feet long. This ribbon is first cut into 200 squares and placed in the "cutch," which is a pile of square pieces of a peculiar paper, part animal and part vegetable in composition, the preparation of which is a secret. A square of gold is placed between each two leaves and the whole mass is ready for the first beating. This is done with an iron hammer, weighing from 12 to 17 pounds, while the cutch rests upon a granite block which is supported by a heavy wooden post.
>
> Under the heavy measured blows of the hammer the sheets of gold begin to stretch or expand until, in half or three-quarters of an hour, they have reached the edges of the cutch. They are then removed and, with a thin strip of bamboo, are cut into quarters, so that the 200 pieces become 800. Next comes the "shoder," a collection of 800 pieces of skin, 4 inches square, made from the intestines of cattle. As in the cutch, each piece of gold is placed between two leaves of skin, and bands of parchment or vellum are slipped over the whole pile to keep it together. Another beating, this time with a hammer weighing from 8 to 10 pounds, now follows. This takes about an hour, during which the sheets of gold are all the time expanding.
>
> The last stage is the "mold," which, like the cutch and the shoder, is composed of alternate leaves of gold and skin, but the mold is about 5 inches square and made up of goldbeater's skin. The preparation of this is a jealously guarded trade secret.
>
> A mold contains 1,000 sheets. After the second beating the workman takes from the shoder a single leaf of gold at a time, handling it with bamboo pinchers and, when necessary, smoothing it with a rabbit's foot. With the strip of bamboo he cuts each sheet into quarters again, so that the original 200 have now become 3,200. One shoder, therefore, contains more than enough gold to fill three molds.
>
> The final beating in the mold is done with a 7-pound hammer and requires from three to four hours. By this time the gold leaf should have expanded again to the edge of the skins and should be of the

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[1] Effects of Arts, Trades, and Professions on Health and Longevity, by C. Turner Thackrah, London, 1832, p. 48.

requisite thinness, which is determined by holding it up to the light. If it transmits green rays, it is done, and will measure about one two-hundred-and-eighty-thousandth ($\frac{1}{280{,}000}$) of an inch in thickness.

The hammers used in beating gold are slightly convex on the face. The art of the workman consists in so striking that the gold will always be thinnest in the center. He must pound with evenness all over the square in order that the sheets of gold may expand without losing their form, but at the same time he must keep the thickest part near the edges, so that when the sheets are finally trimmed to size the thicker portions may fall in the waste to be recast. No machinery has ever been devised which will do this successfully.

The tools of the craft are interesting and peculiar. The rabbit's foot is exceedingly soft and just oily enough to prevent the gold from sticking, and the bamboo pliers and cutting slips are the only things with which it is possible to do this delicate work. The gold does not adhere to the fibers of the reed as it does to steel. The goldbeater performs all this work standing. The use of the heavy hammers in such continuous pounding would, one would think, impose an almost intolerable strain upon the hands and arms. The men say, however, that their arms never ache. The only place where "it catches them" is in the bend of the knee. The lack of strain upon the arms is accounted for by the fact that the hammer rebounds. It is an astonishing but by no means rare thing to see a goldbeater change hands while the hammer is in the air and without losing a stroke.

MORTALITY OF GOLD-LEAF BEATERS—INDUSTRIAL INSURANCE EXPERIENCE.

On account of the limited extent of the occupation there are no general vital statistics, but a fairly trustworthy basis of information is furnished by the proportionate mortality statistics of the Prudential Insurance Co. of America, as given in Table 37.

TABLE 37.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG GOLDBEATERS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, COMPARED WITH THAT OF ALL MALES IN UNITED STATES REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of gold beaters, 1897 to 1914, from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Gold beaters.	Males in registration area, 1900 to 1913.
15 to 24 years	7	3	42.9	27.0
25 to 34 years	12	8	66.7	30.5
35 to 44 years	11	4	36.4	23.4
45 to 54 years	8	2	25.0	14.7
55 to 64 years	4			7.9
65 years and over	11			2.6
Total, 15 years and over	53	17	32.1	13.9

There were 53 deaths from all causes, of which 17, or 32.1 per cent, were from pulmonary tuberculosis. The proportionate mortality was exceedingly heavy at ages under 45, reaching a maximum at ages 25 to 34, when of the mortality of gold beaters from all causes 66.7 per cent was from pulmonary tuberculosis. The rather limited number of observed cases does not warrant final conclusions, but the statistical evidence would seem to confirm the view that the mortality from tuberculosis in this occupation is distinctly above the average.

GENERAL CONCLUSIONS.

The sanitary problems in this industry are complicated by the fact that, as a rule, the work is carried on in small shops in which it is difficult to apply rational principles of factory hygiene. The actual amount of gold dust inhaled is probably relatively small and, in so far as the tuberculosis problem is complicated by the dust factor, it is quite probable that other surrounding circumstances react more unfavorably upon the system than the relatively small amount of metallic dust inhaled during the gold-beating process. As observed by W. Gilman Thompson, "Owing to the value of the metal, where gold is being filed or beaten strong ventilation currents can not be used without dissipating the precious gold dust." Thompson mentions a case personally known to him of a goldbeater's shop "in which there are no general ventilators and the windows have to be kept closed, but at intervals small hoods are let down over the worktables and the room is kept well aired." How far it would be feasible to improve upon this method is merely a matter of conjecture. The industry, while of small extent, is, however, strictly within the classification of unhealthful trades and deserving of more careful attention on the part of the sanitary authorities.

JEWELERS.

The manufacture of jewelry in all its branches involves a large variety of manipulations, including the melting and refining of small quantities of the precious metals, and the handling, shaping, cutting, and polishing of precious stones. An important part of the industry is engraving and die cutting, which, however, for the present purpose, is separately considered as a well-defined occupation, and although often included with jewelers, is equally often included with printers and compositors. Most of the articles made by jewelers are of small dimensions, such as chains, rings, brooches, pins, and buckles, which require painstaking care in handling and continuous eye-straining attention in shaping and polishing. Aside from the use of gold and silver, many other metals and mineral substances are employed, such as jet, coral, tortoise, bone, ivory, etc. Zinc is also extensively used as an alloy and for coloring purposes. The gems must be cut with extreme care, and the work of the diamond polisher and lapidary constitutes, next to that of the gold and silver smith, important separate branches of the trade. The manufacture of artificial gems, made of a paste, chiefly of a vitreous substance prepared from rocks and crystals of flint powder, subsequently treated with nitric acid with lead and borax as a flux, forms another important subdivision of the industry.

ASCERTAINED UNHYGIENIC CONDITIONS.

The work of the jeweler is naturally an indoor occupation, involving a stooping position, much like that of the engraver. The workshops are generally small and the ventilation is usually poor. The dust generated in the processes of hammering, cutting, shaping, grinding, polishing, etc., is considerable, but very minute, and not easily observed. The dust accumulations are preserved and sold to refining plants for remelting and the recovery of precious substances. The health problem is complicated by the universal use of blowpipe apparatus and of gas for heating purposes. In large factories the use of machinery is increasing, but chiefly in connection with the manufacture of imitation jewelry and stones.

The unhygienic condition of many jewelry workshops and the general effect of this employment on health were discussed at some length in an early treatise by Thackrah, from which is quoted the following:

> The jewelers' workrooms are generally crowded, and the atmosphere consequently fouled by respiration, animal effluvia, and the smoke of lamps, as well as by the specific exhalations of the manufacture. Its temperature is generally raised, and in summer the heat is excessive. The labor is light, but the confinement to a leaning posture, with the head much depressed, and the elbows generally fixed to the sides of the trunk, for 10, 14, or 16 hours a day, is irksome and injurious. Intemperance is general, and dram drinking especially prevalent. The disorders of which jewelers principally complain are pains and soreness of the chest, disorders of the stomach and liver, and plethoric affections of the head. They enter the employ at about 13 or 14 years of age and are obliged to abandon it generally at 45 to 50.[1]

Thackrah continues that "an old jeweler is seldom to be found, and leaving work, they seem to leave the world as well." That this rather unfavorable view regarding the health conditions in the jewelers' trade is not exaggerated is made evident by the fairly trustworthy vital statistics of the trade. The English mortality data of jewelers and allied occupations for the three years ending with 1902 include 2,823 deaths from all causes, of which 598, or 21.2 per cent, were from pulmonary tuberculosis.

In addition to a high mortality from pulmonary tuberculosis there were 164 deaths from bronchitis and 247 from other respiratory diseases, a total of 1,009 deaths, or 35.7 per cent, from diseases of the lungs and air passages in the mortality from all causes.[1]

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[1] Effects of Arts, Trades, and Professions on Health and Longevity, by C. Turner Thackrah, London, 1832, p. 115.

DESCRIPTIVE ACCOUNT OF THE JEWELRY INDUSTRY.

The conditions of employment in the jewelry industry, with special reference, however, to England and Wales, have been admirably described by Arlidge, in part as follows:

> Mere dealers in jewelry incur no liability to sickness or to a high mortality, except so far as confinement to their shops and insanitary surroundings concur to produce it. On the other hand, some special health conditions are connected with the manufacture of jewelry—of gold, silver, and precious stones. The incidentals are close, very sedentary work, and with it a bent attitude whilst sitting; close application of the eyes, much artificial light, heat from furnaces, crucibles, and the blowpipe, and acid fumes. The working with precious stones entails the minutest attention and observation, together with strong visual exertion and most delicate manipulation with the fingers and forceps or other tools in use. The lapidary's wheel is a source of dust from the polishing powders used—for the most part rouge, emery, and diamond dust—and, as we learn from Proust (Ann. d'Hygiene Publique, 1878), it is likewise a cause of lead poisoning when a lead cylindrical rod is used for polishing cameos. In this proceeding the cameo is held against the revolving rod, and from time to time moistened with a mixture of tripoli powder and vinegar, whence arises a dust consisting of acetate of lead. Nitric acid is largely employed for dipping and to brighten the surface of jewelry, and where many persons are employed in the same shop, and that not well ventilated, there is enough nitrous acid vapor given off to become a source of throat, chest, and stomach irritation. The frequent contact of the acid also with the skin provokes sores, eczematous eruptions, and cutaneous fissures, besides doing injury to the nutrition of the nails. The leaning position of jewelers over their work aggravates all the other unhealthy incidents of their occupation. The evils of dust production attend the makers of polished steel ornaments in a much higher degree than lapidaries by reason of the larger quantity of polishing materials needed and the constant use of brushes.

Arlidge also directs attention to the sedentary character of the jewelers' work, its confinement, and the bent position long sustained, aside from the more or less injurious but very common method of artificial lighting and the heat proceeding from constantly burning gaslights and gas jets used for blowpipes to melt solder and heat soldering irons. In addition there is the waste of burnt gases, the acid vapors, and last, but not least, the dust from polishing stones and settings, all of which, according to Arlidge, "represent a series of health conditions suggestive of the production of phthisis, bronchitis, anemia, and general debility with digestive troubles—an inference borne out by statistics." He concludes, however, that there is much encouragement in the favorable aspects of the industry, in that the health-injurious conditions referred to are, for the most part, remediable by sanitary arrangements, "foremost among which are ample working space and effective ventilation." These, however, are unfortunately frequently wanting, quite generally so in the smaller establishments.

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[1] The English data include watch and clock makers, makers of scientific instruments, and other more or less closely allied trades. For this reason the English statistics are not strictly comparable with other data for jewelers and are not, therefore, presented here in tabular form.

MORTALITY FROM TUBERCULOSIS AND PNEUMONIA.

Among the watchmakers and jewelers in Scotland, according to the latest published official statistics, "the death rates from tuberculosis and pneumonia are not decidedly different from the corresponding death rates of all males," but the mortality from bronchitis, which is of considerable practical importance in this connection, could not be determined. Since in the corresponding investigations for England and Wales the mortality of jewelers from all causes was fairly normal, it is rather suggestive that in a similar study of the mortality of jewelers in Paris and Switzerland the death rates should have been excessive. The manufacture of jewelry includes, of course, quite a number of specific employments, carried on under widely varying conditions, but no strictly scientific study has been made with a due regard to such variations and the health-injurious circumstances of particular employments as would be necessary for the end in view.[1]

MORTALITY OF JEWELERS—UNITED STATES REGISTRATION AREA.

The mortality of jewelers has been reported upon for the two years 1908 and 1909 by the Division of Vital Statistics of the United States Census Bureau, but no subsequent information has been made public, and the data are therefore of rather limited value. The information includes jewelers, clock and watch repairers, as well as gold and silver workers. According to the census report, out of 686 deaths of jewelers, including those in allied employments, as previously explained, 122, or 17.8 per cent, were from pulmonary tuberculosis. This relatively low average figure for all ages is, however, materially modified by reference to the proportionate mortality according to divisional periods of life. The low average proportion for all ages is accounted for by the peculiar age distribution of jewelers, which, considered as a group, includes quite a large number of deaths at ages 45 and over and a comparatively small proportion at the younger ages. In contrast, for illustration, to the mortality in the printing trades the proportion of deaths of jewelers at ages 45 and over out of the mortality at all ages was 65.2 per cent compared with 44 per cent for printers, lithographers, and pressmen, as derived from the same official American sources. The details of the mortality by divisional periods of life are shown in Table 38.

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[1] Conditions surrounding the industry of jewelry, clock, and watch making in Switzerland are clearly and exhaustively set forth in "Enquête sur le Travail à Domicile chez les Bijoutiers du Canton de Genève," by Dr. André de Maday and Mme. Marthe de Maday-Hentzelt, Geneva, 1911.

TABLE 38.—PROPORTIONATE MORTALITY OF JEWELERS FROM PULMONARY TUBERCULOSIS, UNITED STATES REGISTRATION AREA, 1908 AND 1909, BY AGE GROUPS.

Age at death.	Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent of deaths from all causes.
15 to 24 years	66	33	50.0
25 to 34 years	78	31	39.7
35 to 44 years	94	22	23.4
45 to 54 years	128	18	14.1
55 to 64 years	142	12	8.5
65 years and over	177	6	3.4
Age unknown	1		
Total, 15 years and over	686	122	17.8

It is here shown that the proportionate mortality from pulmonary tuberculosis at the younger ages was quite excessive, having been 50 per cent at ages 15 to 24, and 39.7 per cent at ages 25 to 34. Compared with that of printers, lithographers, and pressmen, however, the proportionate mortality from pulmonary tuberculosis was relatively lower, with one important exception, at all ages over 25. The same conclusion applies to nontuberculous respiratory diseases, as shown in Table 39, which, in the aggregate, account for 8.3 per cent of the mortality from all causes among jewelers against 8.8 per cent among printers, lithographers, and pressmen considered as a group. The table, in a general way, confirms the data derived from other sources, and quite clearly indicates that the health conditions in the jewelry trade are far from satisfactory.

TABLE 39.—PROPORTIONATE MORTALITY OF JEWELERS FROM NONTUBERCULOUS RESPIRATORY DISEASES, UNITED STATES REGISTRATION AREA, 1908 AND 1909.

Cause of death.	Deaths from nontuberculous respiratory diseases.	
	Number.	Per cent of deaths from all causes.
Asthma	2	0.3
Bronchitis	8	1.2
Pneumonia	40	5.8
Other nontuberculous respiratory diseases	7	1.0
Total	57	8.3

MORTALITY OF JEWELERS—INDUSTRIAL INSURANCE EXPERIENCE.

The mortality of jewelers in the industrial insurance experience of the Prudential Insurance Co. of America includes 812 deaths from all causes, of which 238, or 29.3 per cent, were from pulmonary tuberculosis. Of the mortality of jewelers from other respiratory diseases, 61 were from pneumonia, 5 from asthma, 10 from bronchitis, and 7 from other respiratory diseases. The deaths from pulmonary tuberculosis and nontuberculous respiratory diseases combined show that 39.5 per cent of the mortality of jewelers was from diseases of the lungs and air passages. The excess in the mortality from pulmonary tuberculosis among jewelers is very clearly brought out in Table 40, which shows the proportionate mortality from this disease by divisional periods of life.

TABLE 40.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG JEWELERS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, COMPARED WITH THAT OF ALL MALES IN UNITED STATES REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of jewelers, 1897 to 1914, from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Jewelers.	Males in registration area, 1900 to 1913.
15 to 24 years	110	56	50.9	27.0
25 to 34 years	144	84	58.3	30.5
35 to 44 years	106	48	45.3	23.4
45 to 54 years	132	28	21.2	14.7
55 to 64 years	144	16	11.1	7.9
65 years and over	176	6	3.4	2.6
Total, 15 years and over	812	238	29.3	13.9

GENERAL CONCLUSIONS.

The preceding observations and statistical data confirm the conclusion that jewelers as a class are subject to a decidedly excessive mortality from pulmonary tuberculosis at ages under 45, but particularly so at ages 15 to 34, inclusive. There can be no reasonable question of doubt but that this excess is, in a large measure, the direct result of health-injurious circumstances connected with the employment.

THE PRINTING TRADES.

The printing and allied trades give employment to a large number of men and women, including a considerable proportion of young persons. The printing trades have undergone material changes in methods of composition, use of machinery, etc. To an increasing extent composition is done by machines, which are, strictly speaking, type-casting machines, operated in quite a different manner from the old-time process of setting type by hand. The best known of these typesetting machines are the Mergenthaler linotype and the Lanston monotype, both of which are extensively used throughout the country.

LINOTYPE AND MONOTYPE OPERATION.

As observed by Mr. Charles C. Dominge, insurance engineer, in an article on the "Processes and hazards of printing," including stereotyping, electrotyping, etc., in the Weekly Underwriter, August 5, 1911—

> In the case of small job work, small newspapers, pamphlets, and certain books the printing is done direct from the type, which is locked tightly in metal chases and securely fastened in the proper place in the press.

Most of the modern newspaper composition, however, is done by means of linotype and monotype machines, the former of which is described by Mr. Dominge in part as follows:

> These machines derive their name from the fact that they set up one continuous line of type. The machine is operated by means of a keyboard and resembles somewhat a huge typewriter. When the operator strikes a letter on the keyboard the matrices (brass slugs on which is an impression of the desired character) fall down through a channel until a line is made up. Metal followers push the line across until it is dropped in front of a pot of hot type metal, where a chamber is formed around it, of which the brass matrix or type impression makes up one side. A plunger connected with the metal pot ejects a charge of metal into the chamber under pressure, and this metal, coming into contact with matrices, causes a line to be cast. This "line of type" is then pushed off to one side, to be followed by other "lines of type," and the matrices are automatically conveyed and distributed to their respective tubes ready to be called upon again.

The same writer points out as regards the monotype machines that—

> The monotype is perhaps more marvelous in its operations than the linotype. The operator takes the copy and proceeds to write it out on a machine somewhat like a typewriter, except that the result is a long strip of paper with innumerable perforations thereon. There are two perforations for each character, arranged in a series of combinations, the purpose of which will be explained later on. When the operator has written out the "story" upon the strip this paper is placed in position on the casting machine. As the strip moves automatically through the machine two perforations are always brought into position simultaneously over a pair of "lugs," which are forced through the perforations at once by means of compressed air. These lugs govern the lateral direction of a matrix containing 226 characters, which moves laterally in two directions

until stopped by the lugs. Hence the necessity for the different "combinations" in the perforations mentioned above. Molten type metal is then forced against the matrix and a type is cast—not a line, as is the case with the linotype, but a single type. This whole process of casting takes about as long as it takes the average typewriter to strike the keys of her instrument, so rapid is the action of the monotype.

OCCUPATIONAL HAZARDS OF THE PRINTING TRADE.

The occupational hazards of printing are chiefly in connection with the inhalation of a more or less badly contaminated atmosphere. The dust factor, while frequently serious, is, as a rule, of secondary importance to other unhygienic circumstances of the trade. As regards the operation of the linotype and monotype machines it is stated by Dominge that—

> The only hazard in connection with these machines is the lead pot, holding about 1 quart of molten lead, which is usually heated by gas. If the gas connection is made of rigid iron pipe instead of rubber tube, as formerly, the hazard is only moderate. In large shops these lead pots are now heated by electricity, and if approved by the underwriters this is the best arrangement.

There is no reference here to the dust factor which, of course, as a fire hazard is of distinctly secondary, if any, importance.

SANITARY AND MEDICAL CONSIDERATIONS.

The employment of printers differs in many essentials from most of the other occupations considered in this discussion, since it is homogeneous and well defined and common throughout the country. While in many of the modern printing establishments the conditions favoring health and life, with special reference to ventilation and light, are probably satisfactory, in the smaller workshops the sanitary conditions, as a rule, are decidedly to the contrary, and predispose to tuberculosis. Thackrah in 1832 called attention to the diseases of printers, and in his opinion "few appear to enjoy full health." Pulmonary tuberculosis, according to this writer, was frequent, but was apparently caused rather by the confinement or indoor employment than by direct injury to the respiratory organs. The trade is one which has received a considerable amount of attention because of its recognized unhygienic features, and, in addition to the general data upon this subject, the mortality experience of various typographic associations has been carefully investigated. It is suggested by Oliver that "Printing houses should be so constructed that free currents of air can get to them, and not, as is so frequently the case, shut in by other buildings."

But such construction is even to-day the exception rather than the rule. Considering that, as a class, printers probably rank above the average mechanics in intelligence and earnings, it is difficult to understand why they should so persistently in the past have neglected the important problem of workshop hygiene. The successful effort to secure to the members of the craft in illness or old age a home in the mountain region of the West emphasizes what could be done by concentrated effort in other and even more important directions. In the historical sketch of the Union Printers' Home, at Colorado Springs, it is, in fact, pointed out that the place was selected for the location of the home primarily because of the special liability of printers to all forms of lung and throat diseases, and in explanation of the subsequent necessity for a hospital annex the statement is repeated that "consumption is one of the diseases to which the printer is especially liable."

ENGLISH AND AMERICAN MORTALITY STATISTICS.

Tatham, in commenting upon the excessive mortality of printers, as disclosed by an analysis of the English mortality data, remarks that "like bookbinders, printers die very rapidly from phthisis, and probably for a similar reason, namely, because of the excessively unhealthful conditions under which their work is carried on."[1] Tatham calls attention, however, to the decline in the mortality of printers, due among other causes to the decrease in the deaths from lead poisoning, which had fallen to one-half of the earlier figure. The frequency of phthisis among English printers had decreased during the decade by one-sixth of the former rate.

In the occupation mortality statistics of the Twelfth Census, printers are grouped with compositors and pressmen, which is to be regretted since there are certain important differences in the disease liability of these allied employments which are sufficiently distinct to warrant separate consideration, at least in the case of pressmen, although the number of the latter is comparatively small. The total number of persons included in this group in the registration States, aged 15 or over, according to the census, was 54,374, but of this number only 818, or 1.5 per cent, had attained to the age of 65 or over.[2] This rather surprising result is confirmed by the statistics of the New Jersey Bureau of Labor for 1891, according to which out of 462 printers only 2 had attained to the age of 60 or over. The census mortality statistics of this group of printers, or as stated, compositors, printers, and pressmen, are of some value though not entirely conclusive on account of probable defects in the census enumeration.

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[1] Dangerous Trades, by Thomas Oliver, London, 1902, p. 151.

[2] Report of the Bureau of the Census on Vital Statistics, 1900, p. cclxxxii. There has been no subsequent census report giving comparable data.

TABLE 41.—MORTALITY FROM ALL CAUSES AMONG COMPOSITORS, PRINTERS, AND PRESSMEN, COMPARED WITH THAT OF THE MANUFACTURING AND MECHANICAL CLASS AND THE MERCANTILE AND TRADING CLASS, IN THE REGISTRATION STATES, 1900, BY AGE GROUPS.

[Source: Report of the Bureau of the Census on Vital Statistics, 1900.]

Age at death.	Death rate per 1,000 among—		
	Compositors, printers, and pressmen.	The manufacturing and mechanical class.	The mercantile and trading class.
15 to 24 years	5.05	4.43	2.60
25 to 44 years	12.29	8.35	6.72
45 to 64 years	20.01	20.16	19.91
65 years and over	108.80	105.43	93.79

According to Table 41 the death rate of printers at ages 15 to 24 is 5.05 per 1,000, compared with 4.43 for men in the mechanical and manufacturing class, and only 2.60 for the mercantile and trading class. At ages 25 to 44 the rate is 12.29 for printers, but only 8.35 and 6.72, respectively, for the other two selected groups of occupations. At ages 45 and over the differences in the mortality of printers compared with that in other occupations are very slight, due in all probability to the fact that on the one hand most of those at all liable to tuberculosis had died and that on the other many of the impaired in health had left the trade. In addition there is also the factor of a possible defect in the census enumeration.

EXPERIENCE OF THE INTERNATIONAL TYPOGRAPHICAL UNION.

At the forty-sixth session of the International Typographical Union, held at Milwaukee, Wis., in 1900, a statistical summary was submitted showing that out of 419 deaths of printers during the preceding year, 192, or 45.8 per cent, had been deaths from diseases of the lungs or air passages, including under this term bronchitis, asthma, pulmonary tuberculosis, pneumonia, and all other respiratory diseases. Of the 411 printers whose ages at death were known, 44, or 10.7 per cent, died at the age of 65 or over, while the average age at death was only 41.25 years, compared with 52.2 years for all males aged 15 or over in the registration area of the United States in 1900.

Kober, in his article on "Industrial hygiene," in Bulletin No. 75 of the Bureau of Labor Statistics, refers briefly to printers, type founders, and typesetters, quoting Sommerfeld to the effect "that among 38 occupations tabulated by him printers occupied the fifth rank in the number of deaths from tuberculosis." It is to be assumed, of course, that this has reference to the death rate and not merely to the number of deaths without reference to the exposed risk. Kober also quotes Albrecht in the statement that "the statistics of the Berlin Sick

Benefit Insurance Fund, covering a period of 33 years, show that 48.13 per cent of the deaths among printers are caused by consumption." He observes in this connection that—

> This may be due in part to the fact that many weaklings engage in this occupation, but the work itself is often performed in most unfavorable environments and in an impure and dusty atmosphere, which has been found to contain traces of lead, arsenic, and antimony. Special attention should be paid to proper ventilation, and particularly to the collection and removal of dust from the type cases. One gram of this dust has been found to contain 57.7 mg. of lead, 186.8 mg. of antimony, and traces of arsenic.[1] Strasser has suggested a type case with perforated tin bottom, which is placed within another case, so as to facilitate the collection and proper disposition of this injurious form of dust.

The results of an extended investigation into the sanitary conditions of the printing trade, as prepared by Mr. George A. Stevens, were published in the report of the New York State Bureau of Labor Statistics for 1906. This investigation included the entire mortality of the International Typographical Union for the five years ending with 1905, or 2,498 deaths, representing a mean death rate of 12.63 per 1,000. The rate was highest among the printers of New York City, or 16.32 per 1,000, and lowest in Chicago, or 10.12 per 1,000. The average age at death for all printers was not quite 45 years. The disease most frequent and severe among compositors was found to be tuberculosis of the lungs. The average age at death of compositors dying from tuberculosis was only 36.33 years. Out of 2,498 deaths from all causes, 660, or 26.4 per cent, were from tuberculosis, equivalent to an annual mean death rate of 3.34 per 1,000. Pneumonia caused 258 deaths, or 10.3 per cent of the deaths from all causes, equivalent to an annual mean death rate of 1.3 per 1,000. In commenting upon the high degree of frequency of pulmonary tuberculosis the report points out that "scarcely any other occupation furnishes so large a quota of victims from consumption. The domestic life of printers is parallel to that of other artisans in equal financial circumstances. They are fairly compensated for their labor, thus enabling them to have homes as healthful as those procured by the best-paid workmen in any community. Neither can it be said that compositors are ill-nourished and, therefore, rendered more susceptible to the tubercle bacilli. The determining cause of their susceptibility to the harmful process of the great white plague lies in a different direction—neglect of sanitary precautions in composing rooms."[2]

Of the mortality at known ages, from all causes, 18.9 per cent were deaths at 60 years of age and over. Of the 464 deaths in this group,

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[1] Rozsahegyi, Archiv. für Hygiene, Munich and Leipzig, vol. 3, p. 522.

[2] Report of the New York State Bureau of Labor Statistics, 1906, pp. cxxi and cxxii.

321 occurred between the ages of 60 and 69, 122 between 70 and 79, 19 between 80 and 89, 1 at age 90, and 1 at age 96.[1]

COMPARATIVE VITAL STATISTICS OF COMPOSITORS IN THE STATE OF NEW YORK.

The statistics by Stevens indicate a rather wide variation in the incidence of pulmonary and respiratory diseases among printers according to localities, as shown by Table 42.

TABLE 42.—ANNUAL DEATH RATE PER 1,000 FROM PRINCIPAL CAUSES AND ALL CAUSES, AMONG COMPOSITORS IN CERTAIN LOCALITIES, FOR THE FIVE YEARS, 1901 TO 1905.

[Source: Twenty-fourth Annual Report of the New York State Bureau of Labor Statistics, 1906.]

Locality.	Death rate per 1,000.							
	Tuberculosis of lungs and other respiratory organs.	Pneumonia.	Diseases of nervous system.	Diseases of genito-urinary system.	Diseases of the heart.	Diseases of digestive system.	Accidents and injuries.	All causes.
New York City	3.82	2.42	1.91	1.63	1.37	0.99	0.89	16.32
Other New York State	2.54	.97	1.49	.70	1.67	.97	.61	11.14
Total New York State	3.48	2.03	1.80	1.38	1.45	.98	.82	14.94
Chicago, Ill	2.42	1.57	1.04	.98	1.44	.45	.72	10.12
Philadelphia, Pa	3.65	.70	2.26	.70	1.39	.52	....	12.35
All other United States	3.38	1.07	1.33	1.02	1.37	.74	.60	12.20
Total United States	3.34	1.30	1.44	1.08	1.39	.76	.61	12.63
London, England	3.69	.67	1.16	.51	1.97	.51	.19	12.19

EXCESSIVE FREQUENCY OF PULMONARY TUBERCULOSIS.

The corresponding proportionate mortality from pulmonary tuberculosis and other respiratory diseases among compositors varied from 30.2 per cent for London, England, to 26.4 per cent for printers in large cities of the United States, in contrast to a normal average of approximately 15 per cent for adult men and women in the territory under consideration.

As subsequently to be shown, there are reasons for believing that printers are physically below the average of men employed in other gainful occupations and that occupational selection has some bearing upon the excessive mortality from tuberculosis in the printing and allied trades, aside from the special hazard of dust and fume exposure.

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[1] A most important investigation of the health of printers is a recent bulletin (No. 209) of the U. S. Bureau of Labor Statistics (1917), by Dr. Alice Hamilton and Mr. Charles H. Verrill. This investigation includes a concise description of printing plants, observations on the effects of lead fumes and other poisons, descriptive accounts of modern methods of printing by means of linotype and monotype machines, extended observations on the health of printers in the United States and foreign countries, observations on the health conditions of men entering the industry and the health campaign of the International Typographical Union. Appendixes describe a proposed scheme for the inspection of composing rooms in the District of Columbia, precautions for printers published by the Massachusetts General Hospital, and hygienic regulations for printing and type-casting establishments published by the Department of Labor of the State of New York. The report is a model of impartiality and scientific conclusiveness, subject, of course, to the limitations of scientific research inherent in all investigations of this kind.

The statistical data of the mortality rate among printers for the United States are fully confirmed by the corresponding statistics for German printers which were published in a small treatise on the hygiene of the printing trade by Dr. Lewitt, of Berlin, in 1899. According to this authority, out of 1,390 recorded deaths of printers, 798, or nearly 61 per cent, were from diseases of the lungs and air passages, including 630 deaths from pulmonary tuberculosis. Of the total number, 243, or 17.5 per cent of the mortality at known ages, had attained to the age of 60 or over. The suggestions made by this writer regarding the prevention of tuberculosis and other diseases in the printing trade are eminently practical and feasible in most of the workshops in which printers are employed.

SANITARY CONTROL OF THE PRINTING INDUSTRY IN GERMANY.

The regulations of the Federal Council of the German Empire with reference to the control of sanitary conditions in the printing industry, put into effect July 31, 1897, are reprinted in Bulletin No. 75 of the United States Bureau of Labor Statistics, and these regulations as amended in 1907 and in 1908 are reprinted in Bulletin No. 209. The corresponding regulations issued by the Austrian Department of Commerce have been reprinted in a special bulletin (No. 76) on European Regulations for Prevention of Occupational Diseases, published by the New York State Department of Labor, Albany, March, 1916.

DUST HAZARDS IN THE PRINTING INDUSTRY IN OHIO.

The investigations by Hayhurst with special reference to the State of Ohio for the year 1915 include 26 establishments, in 12 of which, however, printing was a more or less auxiliary feature. One of the practical difficulties of separating specific processes in the printing trade is that they are usually all carried on more or less in common. According to Hayhurst—

> Dust was a fair hazard in 10 places, bad in 1, and negligible in the remaining. Quarters were kept clean in 14, fairly so in 9, and not so in 3. Dry sweeping and dusting of fonts with an air blast are pernicious. Cold and dampness, due to inefficient heating, were found to exist in 4 places. Light was good in 17 places, fair in 4, and poor in the remaining 5. General room ventilation was only fair in 10 places and bad in 7 more. Fatigue seemed a negligible factor in 8 places, fair in 10, and bad in the remaining 8, due, principally, to hurrying piecework, monotony, constant standing, strain, chairs and stools without backs, faulty postures, and in some cases jarring

processes and loud noises. Eyestrain and myopia are special hazards of the printers, and every such worker should be assured of the condition of his eyes for such work.

The chief complaints of the employees were with reference to poor ventilation, fumes, typesetting dust, risk of lead poisoning, and working with fellow workers infected with tuberculosis.

Regarding typesetting machines and the special hazard in connection with linotyping, monotyping, stereotyping, etc., Hayhurst, on the basis of personal investigation, writes as follows:

This class of procedure includes all processes in which type metal is melted and used, such as linotyping, monotyping, and stereotyping. (Electrotyping is practically identical with electroplating.) These are here reported upon as the result of our investigation in 15 plants. The total wage earners so employed was 361, of whom 348 were males and 13 were females. Seven of the places were union shops. The general attitude toward employees was good in 12 places, and at least fair in the remaining. The workers were of intelligent type in all places, except here and there a few non-English speaking laborers. Retention of workers was good in 12 places, fair in 1, and not so in 2. Health appliances, such as hoods and stacks over metal pots, furnaces, and burners, were good in 5 places, fair in 2, and absent in the balance.

The dust factor in connection with these occupations was considered of relatively small importance; the chief conditions detrimental to health were the escape of gases and fumes from the hot processes, and the absence of air agitators and means of effective ventilation. Fatigue was not found to be a particular hazard in any one of the working places examined. Industrial poisoning was found to be a considerable hazard in 7 of the work places examined and a fair hazard in 4 others, due chiefly to the absence of hoods and vent pipes over metal pots, especially over gas burners and furnaces.[1]

The actual printing process or pressroom work was investigated by Hayhurst in 13 plants employing 392 wage earners, including 32 females. Health appliances, consisting of hoods and flues for drawing off escaping gas fumes in drying freshly printed work, were present in only 2 places. A slight amount of dust was observed in the air in the majority of places, but no strictly scientific investigations were made with reference to the exact degree of atmospheric pollution.

OCCUPATIONAL DISEASES OF PRINTERS.

Occupational diseases among employees of printing plants have not been made the subject of a thoroughly qualified and strictly scientific investigation.[1] Exact information, however, is gradually increasing, and among other recent investigations is one by Strumpf and Zabel, with reference to the physical condition of a large number of typesetters employed in Strassburg, Germany. According to the Journal of the American Medical Association of December 3, 1910—

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[1] See in this connection Special Bulletin No. 82 of the New York State Department of Labor on "Hoods for Removing Dust, Fumes, and Gases," prepared by the division of industrial hygiene, Albany, May, 1917. See also Public Health Bulletin No. 81, Washington, 1917, on "The Effect of Gas-heated Appliances Upon the Air of Work Shops," by Charles Weissman.

> One thing which impressed them was the rarity of typical cases of lead poisoning. They observed, however, with great frequency, a clinical syndrome characterized by a fatigued expression, nervousness, irritability, insomnia, exhaustion especially in the morning hours, vertigo, headache, particularly in the frontal and occipital regions, general or local muscular pains, neuralgic pains in the extremities, nausea and vomiting, and constipation. Mild, moderately severe, and severe cases were encountered. The authors find evidence in the literature that this symptom-complex has been looked on as a manifestation of chronic lead poisoning. The patients showed no elevation of blood pressure, which, as Krehl has shown, is so common in plumbism from spasm of the arterial walls; the erythrocytes had no basophilic granules; and leucocytosis was lacking. Nor did the urine show traces of albumin or bile. On the contrary, the red count was almost or quite normal even in the severe cases with an absence of basophilic granules and there was leucopenia with eosinophilia between 10 and 25 per cent. (Typesetters without symptoms possessed as high as 9 per cent eosinophiles.[2]) The urine was normal and likewise the blood pressure.

Since the facts observed suggested no connection with lead poisoning, further research led to the conclusion that the employees affected had been suffering from chronic antimony poisoning, subsequently confirmed by further investigations. As pointed out in the editorial of the Journal of the American Medical Association—

> Thus a new danger to typesetters working with antimonial compounds is brought to light and a distinct contribution added to the growing subject of occupational diseases.

CAUSES OF EXCESSIVE FREQUENCY OF PULMONARY TUBERCULOSIS.

Among American printers, using the term in a broad and comprehensive sense, the health conditions have been reported upon by Dr. James Alexander Miller, of New York, in a paper read before the Sixth International Congress on Tuberculosis in 1908. A summary of his more important findings follows:[1]

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[1] A fairly extensive analysis of the available mortality data of printers is included in the bulletin (No. 209) of the U. S. Bureau of Labor Statistics (1917) on the Hygiene of the Printing Trades, by Hamilton and Verrill. To be entirely conclusive, however, a much more specialized technical analysis of the statistical material is required. with a due regard to the strictly medical aspects of a problem of exceptional technical complexity. A really conclusive investigation should include a sufficient number of physical examinations of printers with a due regard to the length of trade life and the various special occupations followed in the printing trade from the beginning of the apprenticeship to the attainment of permanency in the branch of the industry selected as a permanent means of gaining a livelihood.

[2] Eosinophile: In bacteriology and histology, applied to microbes or histologic elements showing a peculiar affinity for eosin stain.

The main point in the investigation was not only to determine the extent of pulmonary tuberculosis but all other diseases were considered both in the history and the physical examination. It was found that almost all the men were young, native-born Americans, earning good wages, and living under good conditions; the majority of them used alcohol and tobacco; 20 per cent of all used them in excess, and about 20 per cent were total abstainers. One hundred and twenty-four complained of unfavorable conditions in the shop designated as follows: Poor ventilation, 49; metal fumes from unpiped machines, 27; insanitary water-closets, 19; insufficient number or absence of cuspidors, 14; dirty walls and ceilings, 8; metal dust, 5; overcrowded rooms, 7; poor light, 5. The medical history and examination showed that catarrh of the upper air passages was frequent, also dry pleurisy, bronchitis, and pulmonary tuberculosis. Pulmonary tuberculosis was present in 34 cases or 17 per cent of the whole number. Dr. Miller concluded that pulmonary tuberculosis is prevalent among printers and is largely due (1) to unfavorable shop conditions, especially poor ventilation, overcrowding, dust and dirt, promiscuous spitting, and poor lighting; (2) to the irregular habits of the printers, especially alcoholism, careless habits of eating, needless exposure to drafts, and insufficient outdoor exercise.[1]

SANITARY CONDITIONS IN GOVERNMENT PRINTING AND ENGRAVING.

A somewhat similar investigation concerning 4,000 persons employed in connection with Government printing and engraving was reported upon by Dr. B. S. Warren, of the United States Public Health Service, at the ninth annual meeting of the National Association for the Study and Prevention of Tuberculosis, Washington, 1913. In part, Dr. Warren states that—

My purpose in writing of this unusual condition is to submit the facts that here are 4,000 employees, working under very bad sanitary conditions, and the death rate is surprisingly low. The force consists of engravers, printers, printers' assistants, examiners, counters, mechanics, and all the help required in such an establishment. All the buildings of this establishment are very badly overcrowded. There are 1,731 employees working with less than 500 cubic feet of air space and 30 square feet of floor space per person. Ventilation is very poor, especially in the pressrooms, where from 150 to 300 printers and printers' assistants are at work. The poor ventilation is made still worse by the small gas stoves required by each printer to heat his plates. Ink fumes and often carbon monoxide rise from these stoves.

The printing is done on piecework basis, and all are working at top speed continuously. In the ink-making rooms the employees are exposed to the dust rising from the dry, powdered colors. In the steel-plate hardening room, cyanide of potash fumes were in the air all the time; in fact, every insanitary condition that surrounds any printing shop was noted.

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[1] For paper in full, see Transactions of the International Congress on Tuberculosis, Washington, 1908, Vol. III, pp. 209-217.

AVERAGE WEIGHT AND HEIGHT OF PRINTERS.

Further and more strictly scientific investigations would be necessary to produce the required evidence regarding the precise effect on health (if at all ascertainable) of the obviously numerous factors and conditions inimical to health in the printing and allied industries. Since the problem is quite complicated, particularly in view of the probably inferior physique of printing employees at entrance to the trade, Table 43, derived from the ordinary mortality experience (males only) of the Prudential Insurance Co. of America, 1886 to 1914, will prove of interest and value.

TABLE 43.—AVERAGE WEIGHT AND HEIGHT OF PRINTING EMPLOYEES COMPARED WITH THOSE OF ALL OCCUPIED MALES, ACCORDING TO MALE ORDINARY MORTALITY EXPERIENCE OF THE PRUDENTIAL INSURANCE CO. OF AMERICA, 1886 TO 1914, BY AGE GROUPS.

Age at entry.	Male printers.			All occupied males.		Average height (inches).	
	Number.	Average 1 weight (pounds).	Relative weight (pounds per inch).	Average weight (pounds).	Relative weight (pounds per inch).	Male printers.	All occupied males.
15 to 24 years	126	140	2.05	145	2.12	68.2	68.1
25 to 34 years	230	149	2.20	155	2.26	67.6	68.3
35 to 44 years	150	154	2.28	160	2.35	67.7	68.1
45 to 54 years	51	159	2.37	163	2.40	67.0	67.9
55 to 64 years	31	154	2.29	163	2.40	67.4	67.8
65 years and over	1	195	2.91	162	2.38	67.0	67.9
Total, 15 years and over	589	149	2.21	157	2.30	67.7	68.1

According to this table, at every period of life the average weight of persons employed in the printing trade, with one exception, is below the average for all occupied males, to the extent of 8 pounds for all ages combined. The one exception at ages 65 and over is, of course, due to the fact that only a single case was under observation. Since there is invariably an important correlation between height and weight, the last two columns of the table are included for the purpose of emphasizing the fact that printers, on examination, were not only below the average in weight, but also in stature. The differences here are not quite so marked as shown by the weight, but they are, nevertheless, of importance.

Correlating the height and weight, the table shows the relative weight at entry in pounds of weight to each inch of stature, proving conclusively a sufficient difference in the physique of printers to require consideration in the correct interpretation of the subsequent mortality tables. The average relative weight of printers, according to this table, was 2.21 pounds per inch of stature, against 2.30 for all occupied males. It may be said in this connection that the proportion of deaths from pulmonary tuberculosis among the 589 printers under observation was 29.2 per cent for all ages, against 18.6 per cent for all occupied males in the company's ordinary experience.

ENGLISH MORTALITY STATISTICS OF PRINTERS.

The most recent English mortality statistics of printers are for the three years ending with 1902, referred to in the Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales, in part as follows:

> The death rates of printers were above the standard for occupied and retired males at all ages up to 35 years, but above that age they were below the standard. Within the main working period of life the comparative mortality figure of printers is 994, which practically corresponds to the standard; they show a slightly excessive mortality from influenza, nervous diseases, and Bright's disease; and their mortality from phthisis exceeds the standard by 60 per cent. On the other hand, their mortality from circulatory and respiratory diseases is considerably below the average, and they appear to be subject to small risk from fatal accident, and to be but little addicted to alcoholism and suicide.
>
> Since 1880–1882 there has been a continuous decline in mortality from phthisis, liver disease, and accident. It is also worthy of notice that the mortality from lead poisoning is now only one-fifth part as high as it was 20 years ago. From the other causes shown in the table the mortality in this occupation has fluctuated considerably.

The English occupation mortality statistics for printers are quite conclusive of the unfavorable effects of this occupation on health. In Table 44, which follows, the mortality from all causes among men in this employment is compared with that of occupied males generally, and the result is decidedly suggestive of conditions in this trade more or less unfavorable to life and health, but in particular at the early ages, or 15 to 34, when the excess in mortality is from 0.45 to 1.62 per 1,000. This table is deserving of particular consideration in that it emphasizes the health-destructive circumstances of this employment at a very early period of life. Among those who survive to age 35 or over there is not apparently a decidedly unfavorable mortality in comparison with other occupations, and in this respect the English statistics are confirmed by the United States census statistics previously quoted. While the actual excess in the mortality of printers at ages 20 to 24 is only 1.62 per 1,000, this excess is equivalent to nearly 40 per cent of the normal mortality at this period of life.

TABLE 44.—MORTALITY FROM ALL CAUSES AMONG PRINTERS, COMPARED WITH THAT OF ALL OCCUPIED MALES, IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[Source: Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 for all occupied males.	Death rate for printers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Per cent of rate for all occupied males.
15 to 19 years	2.44	3.19	+0.75	131
20 to 24 years	4.41	6.03	+1.62	137
25 to 34 years	6.01	6.46	+ .45	107
35 to 44 years	10.22	10.19	− .03	100
45 to 54 years	17.73	17.76	+ .03	100
55 to 64 years	31.01	30.76	− .25	99
65 years and over	88.39	87.61	− .78	99

The preceding table requires no further comment. A more extended comparison, however, is made in Table 45, in which the mortality of printers from pulmonary tuberculosis and other diseases of the respiratory system is compared with the normal mortality of occupied males from these diseases, by divisional periods of life.[1] The comparison shows that at all ages the mortality of printers from pulmonary tuberculosis is excessive by from 0.49 to 2.11 per 1,000. The excess is most marked at ages 35 to 44, but the difference is a material one at all ages, 20 to 64, inclusive. The corresponding mortality from other respiratory diseases among printers was slightly excessive at ages under 20 and comparatively high at ages 65 or over, but below the average at ages 20 to 64, inclusive. Apparently the employment does not predispose seriously to respiratory diseases except such as assume the pulmonary form of true tuberculosis of a rapidly developing type most destructive to young printers at ages under 45. The table which follows is self-explanatory.

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[1] For additional data on the health of printers see table included in the footnote on page 55 for the year 1914 for the city of New York. According to this table, at ages 25 to 34 the proportionate mortality from pulmonary tuberculosis was 66.6 per cent for compositors and printers against 33.5 per cent for all occupations. Every statistical investigation of this kind confirms previous conclusions that the health of printers is unquestionably seriously impaired in consequence of occupational hazards at the present time more or less ill defined and largely a matter of conjecture.

TABLE 15.—MORTALITY FROM PULMONARY TUBERCULOSIS AND FROM OTHER DISEASES OF THE RESPIRATORY SYSTEM AMONG PRINTERS, COMPARED WITH THAT OF ALL OCCUPIED MALES, IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[Source: Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Mortality from pulmonary tuberculosis.				Mortality from other diseases of the respiratory system.			
	Death rate per 1,000 for all occupied males.	Death rate for printers.			Death rate per 1,000 for all occupied males.	Death rate for printers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Per cent of rate for all occupied males.		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Per cent of rate for all occupied males.
15 to 19 years.....	0.54	1.03	+0.49	191	0.24	0.36	+0.12	150
20 to 24 years.....	1.55	3.41	+1.86	220	.48	.37	− .11	77
25 to 34 years.....	2.03	3.65	+1.62	180	.77	.55	− .22	71
35 to 44 years.....	2.74	4.85	+2.11	177	1.66	1.24	− .42	75
45 to 54 years.....	3.04	4.27	+1.23	140	3.32	2.17	−1.15	65
55 to 64 years.....	2.16	3.42	+1.26	158	6.54	5.16	−1.38	79
65 years and over.	1.11	1.60	+ .49	144	17.77	20.76	+2.99	117

FACTS DISCLOSED BY THE NEW YORK STATE FACTORY INVESTIGATING COMMISSION.

There are no other recent mortality statistics for American printers obtainable through census investigations or the annual reports of State and local boards of health than those subsequently to be referred to. The most recent investigation of the existing labor conditions in the printing trade was made in connection with the work of the New York State Factory Investigating Commission. According to this investigation 2,245 workers were employed in 25 establishments, including 60 per cent male employees, 39 per cent females, and 1 per cent children under 16; 14 per cent of the employees were found to be working in dirty shops, and 86 per cent were at work in fairly clean or clean quarters. The statement is made that "Printers have improved in health and have suffered less from lead poisoning since the handling of type and inhaling of dust from the cases have been so largely superseded by the newer processes." But it is added that there are still evils to be remedied, and special reference is made to air contaminated by fumes from linotype machines not provided with adequate ventilating devices. Some of the shops investigated were found to require better ventilation with special reference to gas or lead fumes. A large number of pressmen and paper handlers were found to be subject to a high degree of heat and humidity, owing to the need for quick drying and smooth flow of the ink. The dust factor is obviously less important than gas and fumes and unsuitable atmospheric conditions, but, as said in the report of the same commission for the year 1913, "There is a total lack of adequate provision for ventilating printing establishments. The abundant dust from the type, the fumes from the molten lead, the particles of graphite from the stereotyping processes, the heat from the artificial illumination and from the gas-heated lead pots in the linotype, all these cause extreme vitiation of the air in such establishments." The investigations of the commission ascertained that mechanical ventilation was made use of in only 6 per cent of the shops. The statistical data of the commission are amplified by an extended review of the health of the workers, including many interesting and useful observations derived from foreign sources.

SPECIAL OCCUPATIONAL HAZARDS IN THE PRINTING TRADES.

In reply to the question, "What are the dangers in the trade or conditions injurious to the workers?" it is said that—

> As has been stated, the chief dangers are lead poisoning and tuberculosis. Lead poisoning is caused by the lead dust which is so common in printing shops, and also by the fumes arising from the lead in the various processes of machine composition. The dust in the shops, especially that in the type boxes, contains a large amount of lead and some antimony. Prof. Steingraber analyzed the dust from a type box in Cracow and found it contained 16.43 per cent of lead. Dust from the top of stove in a composing room contained 0.24 per cent of lead, while that from the floor of a gallery 16.4 feet high in the composing room contained 0.37 per cent of lead. Much of the lead dust is undoubtedly inhaled by the workers. A great deal of dust is raised by the foolish and highly insanitary method so prevalent in old printeries of cleaning the dust out of the type boxes with bellows. Much lead dust is also deposited on the fingers and hands of the workers as well as upon their clothes, and remains there from lack of proper washing facilities. The dust is very often ingested with their food, which is commonly eaten at the workstand in the printing shop.[1]

These observations are in strict conformity to the facts and are suggestive of health-injurious conditions which have not heretofore received the required consideration. As observed by the New York State Factory Investigating Commission in their second report—

> Grave as are the dangers to the life and health of male workers in the printing industry, these are still greater in the case of women. It is well known that women are more subject to lead poisoning than men, and their general constitution is apt to fall a prey to the dangers of the trade sooner than that of the more robust male workers.

Attention is also directed to the prevalence of tuberculosis among young persons employed in printing trades, and it is pointed out that—

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[1] New York State Factory Investigating Commission, Second Report, 1915, Vol. II, p. 525.

Not only has legislation been introduced to limit the work of minors in this trade, but in England as well as Germany stringent medical examination is made of all minors entering this industry, and a large number of applicants rejected. The opinion is prevalent that no minors under 18 should be allowed to work in printing establishments, and then only after a thorough physical examination. Hahn as well as Teleky advocate a thorough medical examination of all workers in lead every three months, especially minors.

MORTALITY OF PRINTERS—UNITED STATES REGISTRATION AREA.

Printers, lithographers, and pressmen, considered as a group, have been reported upon for the years 1908 and 1909 by the Division of Vital Statistics of the United States Census Bureau, but no subsequent information has been made public, and the data are therefore restricted to the two years referred to; in fact, the mortality of lithographers included in the group is for 1909 only. The data are of rather limited value, but on account of the large number of deaths included the conclusions may be accepted as representative for the printing trade. According to the census report, out of 2,847 deaths of printers, lithographers, and pressmen from all causes, 840 or 29.5 per cent were from pulmonary tuberculosis. The details of the mortality by divisional periods of life are shown in Table 46.

TABLE 46.—PROPORTIONATE MORTALITY OF PRINTERS, LITHOGRAPHERS, AND PRESSMEN FROM PULMONARY TUBERCULOSIS, UNITED STATES REGISTRATION AREA, 1908 AND 1909, BY AGE GROUPS.

Age at death.	Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent of total deaths.
15 to 24 years	427	186	43.6
25 to 34 years	551	278	50.5
35 to 44 years	614	223	36.3
45 to 54 years	522	112	21.5
55 to 64 years	350	27	7.7
65 years and over	381	14	3.7
Unknown	2		
Total, 15 years and over	2,847	840	29.5

TABLE 47.—PROPORTIONATE MORTALITY OF PRINTERS, LITHOGRAPHERS, AND PRESSMEN FROM NONTUBERCULOUS RESPIRATORY DISEASES, UNITED STATES REGISTRATION AREA, 1908 AND 1909.

Cause of death.	Nontuberculous respiratory diseases.	
	Number.	Per cent of total deaths.
Asthma	2	0.1
Bronchitis	14	.5
Pneumonia	193	6.8
Other nontuberculous respiratory diseases	41	1.4
Total	250	8.8

Table 46 indicates conclusively an exceptionally high degree of frequency of pulmonary tuberculosis among men employed in the printing trade, and particularly so during the early years of life. At ages 25 to 34, for illustration, the proportionate mortality from pulmonary tuberculosis was 50.5 per cent, which is exceeded by the corresponding figure for few other trades or occupations with continuous and considerable exposure to inorganic dust. The table in a general way confirms the data derived from other sources and quite clearly suggests the relative unhealthfulness of employment in the printing trade, subject, of course, to the qualification that adverse physical occupational selection, as elsewhere pointed out, may materially affect the mortality returns. It may be said in this connection, however, that the mortality from nontuberculous respiratory diseases, as shown in Table 47, was 8.8 per cent of the mortality from all causes, which compares, for illustration, with 12.2 per cent for marble and stone cutters and 12.5 per cent for potters, according to mortality returns derived from the same official American sources.

MORTALITY OF PRINTERS—INDUSTRIAL INSURANCE EXPERIENCE.

The observations and conclusions of the New York State Factory Investigating Commission are in conformity with the results of other investigations, and are sustained by the insurance mortality statistics. Table 48 shows the results of the mortality experience of the industrial department of the Metropolitan Life Insurance Co. for the three years 1911 to 1913. The experience is limited to white males.

TABLE 48.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AND PNEUMONIA AMONG COMPOSITORS AND PRINTERS, METROPOLITAN LIFE INSURANCE CO., INDUSTRIAL EXPERIENCE, 1911 TO 1913, BY AGE GROUPS.

[Compiled from Bul. 207, U. S. Bureau of Labor Statistics, pp. 33, 34.]

Age at death.	Deaths of printers and compositors, 1911 to 1913, from—		Per cent of deaths from pulmonary tuberculosis among—		Deaths of printers and compositors, 1911 to 1913, from pneumonia.	
	All causes.	Pulmonary tuberculosis.	Printers and compositors.	Males in registration area, 1900-1913.	Number.	Per cent.
15 to 24 years	217	98	45.2	27.0	10	4.6
25 to 34 years	221	110	49.8	30.5	16	7.2
35 to 44 years	225	88	39.1	23.4	6	2.7
45 to 54 years	176	42	23.9	14.7	9	5.1
55 to 64 years	120	19	15.8	7.9	7	5.8
65 years and over	97	3	3.1	2.6	4	4.1
Total, 15 years and over	1,056	360	34.1	13.9	52	4.9
Average age at death	40.2	33.5	....	....	39.7	....

According to this table, out of 1,056 compositors and printers, 360, or 34.1 per cent, died of tuberculosis of the lungs, at an average age of 33.5 years. In addition there are 52 deaths from lobar and undefined pneumonia, accounting for 4.9 per cent of the mortality from all causes, at an average age at death of 39.7 years.

The investigation of the Metropolitan Co. includes also an extended study of the mortality of printers from other diseases than pulmonary tuberculosis. The details of the analysis are given in an abbreviated form in the table below, which has been derived from Bulletin 207 of the United States Bureau of Labor Statistics, on "Causes of Death by Occupation."

TABLE 49.—NUMBER AND PER CENT OF DEATHS FROM SPECIFIED CAUSES AMONG COMPOSITORS AND PRINTERS, BY AGE PERIODS, 15 YEARS AND OVER—WHITE MALES.

[Metropolitan Life Insurance Co.—Industrial department—Mortality experience, 1911 to 1913.]

Cause of death.	Ages 15 years and over.		Per cent of deaths during age period (years)—					
	Number.	Per cent.	15-24	25-34	35-44	45-54	55-64	65 and over.
Number of deaths	1,056	....	217	221	225	176	120	97
Typhoid fever	22	2.1	3.2	4.5	1.8	0.6	....	....
Tuberculosis of the lungs	360	34.1	45.2	49.8	39.1	23.9	15.8	3.1
Cancer (all forms)	28	2.7	.9	.5	1.3	5.1	5.0	7.2
Cerebral hemorrhage, apoplexy, and paralysis	38	3.6	....	.9	2.2	6.8	5.8	12.4
Organic diseases of the heart	118	11.2	6.0	5.9	10.2	13.1	19.2	23.7
Pneumonia (lobar and undefined)	52	4.9	4.6	7.2	2.7	5.1	5.8	4.1
Cirrhosis of the liver	19	1.8	.5	.5	1.3	2.3	6.7	2.1
Bright's disease	94	8.9	1.4	3.6	10.7	18.2	11.7	13.4
Suicide (all forms)	19	1.8	3.2	3.2	1.3	.6	....	1.0
Accidental violence	62	5.9	10.1	5.4	4.8	7.4	1.7	2.1
All other causes	244	23.1	24.9	18.8	24.4	17.1	28.3	30.9
Total	1,056	100.0	100.0	100.0	100.0	100.0	100.0	100.0

In connection with the table it is said in the text by Dr. Louis I. Dublin, the author of the report, that—

In the age period 15 to 24 the relative index of tuberculosis of the lungs is high (133.7); this cause accounts for 45.2 per cent of all deaths, as against 33.8 per cent in the general group. Accidental violence has a low index (52.6). In the period 25 to 34 tuberculosis of the lungs is somewhat lower than in the previous age period, though still high (121.8). Bright's disease is low (80.0) and accidental violence is still lower (43.2). In the age period 35 to 44 tuberculosis of the lungs (118.8) and organic diseases of the heart (132.5) are both high. Bright's disease is high (137.2). Pneumonia is very low (33.3). Both suicide (44.8) and accidental violence (48.5) exhibit low relative indices. In the age division 45 to 54 the high relative index for tuberculosis of the lungs is maintained (129.2). Cerebral hemorrhage, apoplexy, and paralysis loom up as important in this age period; the relative index is 130.8. The index for pneumonia remains low (62.2); Bright's disease is even higher than in the previous age period (164.0). Suicide remains low as before (23.1), and accidental violence shows an increase over the previous age period (87.1). In the age period 55 to 64 tuberculosis of the lungs shows a very high relative index (183.7). Organic diseases of the heart (120.8) are somewhat higher than the average and pneumonia is lower (77.3). Accidental violence is very low (26.2). There are no cases of suicide in this age group. In the age period 65 and over the cases in which variations from all occupations are noted are too few to warrant discussion.

With special reference to tuberculosis it is said that confirmatory data are provided by the returns of the United States Census, the reports of the Registrar-General, and the experience of the Prudential. All of the index figures derived from these sources are higher than those of the Metropolitan experience. The high proportionate mortality definitely marks this occupation as one in which the environment favors the development of pulmonary tuberculosis. All investigators are agreed as to this, yet there is a diversity of opinion as to the exact causative factor.

As regards the possible effect of lead dust, it is said that in the Metropolitan experience, out of 1,056 deaths of printers and compositors from all causes only 4 were from lead poisoning. It, however, is explained that "It must not be inferred that the exposure to lead is not a serious factor in the causation of tuberculosis. A similar relation has been suggested between lead poisoning and Bright's disease, which also shows a high proportionate mortality in the age periods 35 to 44 and 45 to 54, the relative indices being 137.2 and 164.0, respectively."

The experience of the Metropolitan Co. is fully confirmed by the more extended data derived from the industrial experience of the Prudential Insurance Co. of America for the period from 1897 to 1914, inclusive:

TABLE 50.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG PRINTERS AND COMPOSITORS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of printers and compositors, 1897 to 1914, from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Printers and compositors.	Males in registration area, 1900 to 1913.
15 to 24 years	795	368	46.3	27.0
25 to 34 years	904	505	55.9	30.5
35 to 44 years	851	350	41.1	23.4
45 to 54 years	567	141	24.9	14.7
55 to 64 years	427	42	9.8	7.9
65 years and over	318	14	4.4	2.6
Age unknown	1			
Total, 15 years and over	3,863	1,420	36.8	13.9

The mortality of printers in the industrial-insurance experience of the Prudential Co. includes 3,863 deaths from all causes, of which 1,420, or 36.8 per cent, were from pulmonary tuberculosis. Of the mortality of printers from other respiratory diseases, 343 were from pneumonia, 19 from asthma, 35 from bronchitis, and 55 were from less frequent respiratory diseases. If the deaths from pulmonary tuberculosis and nontuberculous respiratory diseases are combined, 48.5 per cent of the mortality of printers was from diseases of the lungs and air passages. The excess in the mortality from tuberculosis among printers is decidedly suggestive of a typical indoor employment where the exposure to the inhalation of metallic dust, complicated by more or less injurious gases and fumes, is continuous and, in a measure, unavoidable. While, as shown by Table 50, the mortality from pulmonary tuberculosis among printers is excessive at all ages, the excess is most pronounced at ages 25 to 34, when out of every 100 deaths from all causes 55.9 are from pulmonary tuberculosis, against a normal expected proportion of 30.5 per cent. The preceding observations and statistical data derived from American and foreign sources, including extensive industrial-insurance experience data, fully confirm the conclusion that the printing trade is unquestionably subject to decidedly unfavorable health conditions more or less predisposing to a high degree of tuberculosis frequency. The data suggest the necessity for an improvement in shop conditions in conformity with the Austrian and Swiss regulations covering sanitation in the printing trade.[1]

MORTALITY OF PRINTERS—MEDICO-ACTUARIAL EXPERIENCE.

The data as to height and weight prove that a large proportion of printers are physically below the general average, and by implication they suggest the great practical importance of a physical examination on entrance and of a physical reexamination from time to time for the purpose of ascertaining the earliest indications of physical impairment. Life insurance companies have never discriminated against journeymen printers and compositors, and a large number have been insured on the ordinary plan or with fraternal insurance organizations. Since applicants for ordinary or fraternal insurance are, however, subjected to a fairly rigid medical examination, this class of risks would not be strictly representative of the general average. The results of the medico-actuarial investigation with regard to journeymen printers and compositors can not, therefore, be considered entirely conclusive. The results, however, are shown in Table 51.

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[1] See in this connection the proportionate mortality data for New York City printers by divisional periods of life and comparative data for selected occupations as given in footnote to page 55.

TABLE 51.—MORTALITY FROM ALL CAUSES AMONG JOURNEYMEN COMPOSITORS, BY AGE GROUPS—MEDICO-ACTUARIAL INVESTIGATION.

Age at death.	Number exposed to risk one year.	Actual deaths.	Expected deaths.	Per cent actual are of expected deaths.
15 to 29 years	6,428	35	29.64	118
30 to 39 years	3,706	20	21.23	94
40 to 49 years	962	7	9.58	73
50 to 59 years	261	6	4.95	121
60 years and over	21	....	1.04	....
Total, 15 years and over	11,378	68	66.44	102

According to this table the actual mortality of the risks under consideration is 102 per cent, being highest at the two extremes, or 118 per cent at ages 15 to 29, and 121 per cent at ages 50 to 59. The table would seem to prove that the health-injurious effects of the printing trade are most pronounced in youth and after middle age. It would make a valuable contribution to the scientific study of the subject if the statistics of the International Typographical Union could be subjected to a critical analysis. The same conclusion applies to the experience which has been had with sanatorium treatment at the home for sick and aged printers in Colorado.

SPECIAL CONSIDERATION OF THE MORTALITY AND DISEASE LIABILITY OF COMPOSITORS.

Compositors, considered as a distinct occupation (for many printers are also compositors), are exposed to practically the same health-injurious conditions as are persons engaged in the other occupations of the printing business, and in addition they suffer from eyestrain, which may, under given conditions, affect very seriously the disease-resisting capacity of the system. Stereotyping might have been included here, and its enormous development as a separate branch of the printing trade would warrant special consideration if any really authenticated observations had been made a matter of record useful for the present purpose. In stereotyping, the liability to lead poisoning is a serious factor, affecting especially the men employed in melting the alloy and ladling it into the forms.[1] The same observation applies to operatives on linotype machines, but our present information regarding these employments is too indefinite to warrant the conclusion that the exposure to the risk of plumbism increases materially the mortality from tuberculous and respiratory diseases.

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[1] Stereotyping is fully described in the report by Hamilton and Verrill on the "Hygiene of the Printing Trades" (Bulletin of the United States Bureau of Labor Statistics No. 209), including references to the findings of the Illinois Commission on Occupational Diseases as regards the occurrence of cases of lead poisoning. Stereotypers were apparently most liable, proportionately to the numbers exposed to risk. According to Hayhurst the proportion of lead poisoning among linotypers was 3½ per cent against 7.6 per cent among stereotypers.

There are no general vital statistics of compositors separate from those of printers and pressmen, since in both American and foreign statistics these employments are considered as a group.

There is included here a brief extract from a letter by Mr. J. W. Sullivan, a New York City printer, in the Typographical Journal for November, 1903, and reprinted in the annual report of the New York State Bureau of Labor Statistics for 1906, reading in part as follows:

> Typesetting is exhaustive work. Standing hour by hour brings on backache, and in some men varicose veins and swollen feet. Sitting on the high printing-office stools doubles the typesetter up, constraining his arm motions and interfering with his digestion. The linotype operator's stool is too low, as it throws his legs into cramped positions. From the pot of molten type-metal under his machine comes a trying heat and offensive gases. He must watch the delicate machinery lest it go wrong. The electric light thrown on his copy often sharply conflicts with the daylight. His keyboard work with wrist and fingers and his handling of hot slugs sometimes results in numbness that threatens scrivener's palsy. Whether typesetter or linotype operator, the compositor's brain is active every moment during the workday. Composition can never be wholly mechanical. Attention must be given to deciphering the copy, to spelling, to capitalizing, punctuating, office style, and correcting the lines as composed. Each of these distinct mental acts, on the whole tedious and monotonous, helps to drain the bodily forces. As the brain becomes fatigued its cells shrink. With every type a man sets there is a touch of wear on the cerebral tissue itself, only to be repaired by the restorative operations of nature—through food, rest, and sleep.

SPECIAL CONSIDERATION OF THE MORTALITY AND DISEASE LIABILITY OF PRESSMEN.

Pressmen in printing plants may also be separately considered, although the information regarding this occupation is rather fragmentary and inconclusive. Arlidge comments on the hygienic aspects of the employment in part as follows:

> Their old mode of working has been superseded by the wonderful development of the modern printing machine, whereby the pressman has become little else than an attendant upon it; and we see the marvelous machine in newspaper offices strike off. fold, and count the sheets by thousands in an hour. Bodily strength is consequently at a discount, and the disadvantages of the occupation limited to the heat of the pressroom—caused principally by the heated cylinders of the press, and to a greater or smaller extent, where coal gas and not electricity is used for lighting, by the gas jets. Add to these the noise of the machines, the standing posture, and confinement in the pressroom and sustained attention to their work, and there remains nothing else calculated to injure the pressman's health, barring circumstances within his own control.

The occupation of pressmen does not appear to have attracted the special attention of American writers on occupation mortality, but it is safe to assume that the disease liability of this class, and in particular the degree of frequency of pulmonary tuberculosis, do not materially differ from the observed mortality of men employed in the printing trade generally. More definite data, however, would supply a much to be desired addition to our at present very limited knowledge regarding the specific occupation mortality of this employment.

MORTALITY OF PRESSMEN—MEDICO-ACTUARIAL EXPERIENCE.

The only available mortality data regarding pressmen as differentiated from compositors are the medico-actuarial statistics, which, of course, are inclusive of deaths from all causes and not with special reference to tuberculosis. The number exposed to risk, especially at the younger ages, was relatively fairly large, and the experience shows that the actual mortality was 117 per cent of the expected, in contrast to 102 per cent for journeymen compositors. The data in detail are given in Table 52.

TABLE 52.—MORTALITY FROM ALL CAUSES AMONG JOURNEYMEN PRESSMEN, BY AGE GROUPS—MEDICO-ACTUARIAL INVESTIGATION.

Age at death.	Number exposed to risk one year.	Actual deaths.	Expected deaths.	Per cent actual are of expected deaths.
15 to 29 years	5,674	32	25.99	123
30 to 39 years	3,012	15	17.02	88
40 to 49 years	976	10	9.29	108
50 to 59 years	310	11	6.93	159
60 years and over	15	2	.51	392
Total, 15 years and over	9,987	70	59.74	117

This table is exceptionally interesting, in that it confirms the results of the previous analysis of the mortality of journeymen compositors, showing an excessive death rate from all causes at ages under 30 and at ages over 50. It suggests the practical value of further and more specialized inquiries in connection with the different branches of the printing trade. It is of interest in this connection to draw attention to the industrial mortality experience of the Prudential Co., which, in a general way, confirms the results of other investigations.

TABLE 53.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG PRESSMEN, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of pressmen, 1897 to 1914, from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Pressmen.	Males in registration area, 1900 to 1913.
15 to 24 years	168	72	42.9	27.0
25 to 34 years	151	72	47.7	30.5
35 to 44 years	116	51	44.0	23.4
45 to 54 years	45	9	20.0	14.7
55 to 64 years	27	3	11.1	7.9
65 years and over	16	....	....	2.6
Total, 15 years and over	523	207	39.6	13.9

GENERAL CONCLUSIONS.

The mortality of pressmen from pulmonary tuberculosis is shown to be somewhat more favorable at the earlier ages than the corresponding mortality of printers and compositors, but for the later age groups the numbers are insufficient for a safe conclusion. In a general way the differences are not sufficiently pronounced to suggest material variations in the occupational hazards of the more important occupational groups of the printing trade. At all ages it is shown in Table 53 that out of 523 deaths from all causes among pressmen, 207, or 39.6 per cent, are from pulmonary tuberculosis, against a normal proportion of 13.9 per cent among males in the United States registration area. The statistical evidence is therefore decidedly suggestive of more or less health-injurious conditions common to this particular occupational group, which are elsewhere shown to prevail in the printing trades generally.

In this connection attention may be directed to an exceptionally carefully considered set of precautions for printers published by the New York City Department of Health, through its division of industrial hygiene, and published in the Monthly Review of the United States Bureau of Labor Statistics, for December, 1915. The suggestion made in these rules regarding the necessity of avoiding lead dust should, however, be amplified to apply to the avoidance of all forms of metallic or mineral dust common to the printing trades generally.

ENGRAVERS.

Engravers are a fairly numerous and widely distributed class of workmen, whose occupation is sufficiently well defined to warrant separate consideration. According to the census of 1910 there were 11,766 engravers in the United States. Engravers upon copper, steel, or other metals are subject to much the same conditions injuriously affecting health and life, and the differentiation of the employment according to the kind of metal worked upon is not practicable.

The employment decidedly predisposes to tuberculosis, and all the available data indicate an excessive proportion of deaths from this disease among engravers, at least during the active working period of life. Aside from health-injurious factors directly resulting from operations and processes inseparable from the employment, there is also the unfavorable effect of a sedentary occupation demanding a fixed and stooping position. Arlidge has called attention to the fact that there are other accessory conditions unfavorable to health in this employment, such as the frequent use of strong light, severe taxing of the eyes,[1] and the employment of strong acids.

Some fairly conclusive data are available regarding the mortality of engravers, with particular reference to pulmonary tuberculosis, but as an interesting case of extreme longevity mention may be made of a Mr. Charles Harris, who died at the age of 93, and who for more than half a century had been an engraver of the American Bank Note Co. A somewhat similar case was that of a Mr. James P. Mayer, who, at the time of his death at the age of 83, was reputed to be the oldest steel engraver in America.

RELATIVE FREQUENCY OF PULMONARY TUBERCULOSIS.

These, however, are but illustrations of exceptions and rather mark the rule of the comparative infrequency of extreme longevity among men in this employment. Thackrah held that "engravers and copper plate printers present few examples of old age," and he may have included printers and lithographers and similar employments under this term. Tracy, writing with reference to more recent and American conditions, holds that engravers, in common with lapidaries and watchmakers, are very liable to phthisis. It is probably quite true, as pointed out by Sommerfeld, that the amount of metallic or mineral dust generated in this occupation is comparatively small in quantity, but it is practically certain to be injurious in its effects just because of the minuteness of the particles. According to Sommerfeld's data, 23.6 per cent of all cases of sickness of engravers were diseases of the lungs and air passages. He suggests, among other things, as a precaution, extreme care in the physical selection of engravers' apprentices to eliminate those already predisposed to pulmonary tuberculosis. He further advises the proper ventilation of the workshops, which in most cases is almost entirely neglected.

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[1] For an extended discussion of the cause of eyestrain, see Biographic Clinics, Vol. IV, by George M. Gould, M. D., Philadelphia, 1906, p. 61 et seq.; also Popular Science Monthly for December, 1905.

MORTALITY OF ENGRAVERS—UNITED STATES REGISTRATION AREA.

The mortality of engravers has been reported upon for the year 1909 by the Division of Vital Statistics of the United States Census Bureau, but no subsequent information has been made public, and the data are, therefore, limited to the year referred to. According to the census report, out of 112 deaths of engravers from all causes 23, or 20.5 per cent, were from pulmonary tuberculosis. The details of the mortality by divisional periods of life are shown in Table 54.

TABLE 54.—PROPORTIONATE MORTALITY OF ENGRAVERS FROM PULMONARY TUBERCULOSIS, UNITED STATES REGISTRATION AREA, 1909, BY AGE GROUPS.

Age at death.	Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent of deaths from all causes.
15 to 24 years	10	5	50.0
25 to 34 years	23	8	34.8
35 to 44 years	20	5	25.0
45 to 54 years	15	1	6.7
55 to 64 years	19	3	15.8
65 years and over	25	1	4.0
Total, 15 years and over	112	23	20.5

According to this table the mortality from pulmonary tuberculosis is relatively high at the younger ages, but the data are too limited for entirely safe conclusions. In a general way, however, they confirm other statistics derived from American and foreign experience. As shown in Table 55, the mortality of engravers from nontuberculous respiratory diseases was relatively low, or only 3.6 per cent of the mortality from all causes, the deaths being limited to pneumonia and other nontuberculous respiratory diseases, excluding asthma and bronchitis.

TABLE 55.—PROPORTIONATE MORTALITY OF ENGRAVERS FROM NONTUBERCULOUS RESPIRATORY DISEASES, UNITED STATES REGISTRATION AREA, 1909.

Cause of death.	Deaths from nontuberculous respiratory diseases.	
	Number.	Per cent of deaths from all causes.
Asthma		
Bronchitis		
Pneumonia	3	2.7
Other nontuberculous respiratory diseases	1	.9
Total	4	3.6

MORTALITY OF ENGRAVERS—INDUSTRIAL INSURANCE EXPERIENCE.

A large number of engravers are employed by the Bureau of Engraving and Printing of the United States Government, which in the past had most of its bank notes and postage stamps printed by private concerns. In former years no doubt serious objections were properly raised against the conditions under which Government employees were at work in the Bureau of Engraving and Printing; but most of the earlier disadvantages have been done away with. The health conditions have correspondingly improved and the more or less inevitable degree of dust exposure has been reduced to a minimum. The vital statistics of this branch of the Government service if published would be of considerable practical value. At the present time the only available data are the industrial insurance mortality statistics for the period 1897 to 1914, covering 384 deaths, of which 127, or 33.1 per cent, were from pulmonary tuberculosis. The details of this analysis are given in Table 56.

TABLE 56.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG ENGRAVERS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, COMPARED WITH THAT OF ALL MALES IN UNITED STATES REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of engravers, 1897 to 1914, from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Engravers.	Males in registration area, 1900 to 1913.
15 to 24 years	71	28	39.4	27.0
25 to 34 years	92	50	54.3	30.5
35 to 44 years	74	35	47.3	23.4
45 to 54 years	63	10	15.9	14.7
55 to 64 years	41	3	7.3	7.9
65 years and over	43	1	2.3	2.6
Total, 15 years and over	384	127	33.1	13.9

GENERAL CONCLUSIONS.

The general conclusions regarding engravers, including photo-engravers, are briefly summarized by Dr. Kober, in Kober and Hanson's Diseases of Occupation and Vocational Hygiene (p. 615), as follows:

> The work of engraving upon steel, copper, or other material involves not only considerable eyestrain, but also, in the absence of suitable work benches, a faulty position which interferes with the respiratory movements. Steel and copper plate engravers are also exposed to mercury, and makers of stamping devices and seals to lead and the fumes of nitric acid. The latter agent is likewise employed in mints in connection with the coinage of money. According to Sommerfeld, cited by Zadek, 73.6 per cent of all the deaths

among this class of workers in Berlin were caused by diseases of the respiratory system, inclusive of 62.1 per cent from tuberculosis; this is in part accounted for by the fact that so many weaklings engage in this pursuit. Visual defects, neurasthenia, and diseases of the digestive system are also quite common. Plate printers who have to look constantly at bright plates suffer not only from eyestrain but occasionally also from conjunctivitis and even retinitis. Photo-engravers handle benzol for dissolving rubber films, alcohol, and ether, in collodium films, strong acetic acid for the removal of films; they are also exposed to gas fumes and ammonium dichromate in sensitizing copper plates, and to ferric chloride and nitric acid fumes in etching. The Report of the Photo-engravers' Union for 1914, cited by Hayhurst, discloses the fact that out of 217 deaths since 1903, 88, or nearly 41 per cent, were due to tuberculosis. During the year 1914 five cases of bichromate and one case of cyanide poisoning were reported.

Apparently the dust hazard is, by the writer, considered of minor importance, which is not in conformity with the results of specialized statistical investigations into the mortality of engravers and allied occupations. Specific occupational diseases are unquestionably of considerable scientific interest, but they are of minor importance in comparison with the excessive amount of pulmonary tuberculosis directly or indirectly attributable to the employment, and more or less subject to control by effective methods of sanitation.

BRASS WORKERS.

Brass workers, exclusive of brass polishers and buffers, who have been separately considered, constitute a large group of widely diversified and often quite different employments. Brass casting, founding, and molding are arduous occupations exposing to the inhalation of considerable quantities of mineral dust more or less mixed with metallic ingredients. Whether brass dust, as such, is more injurious than the dust of iron and steel, for illustration, has not been determined. In the evidence submitted to the Departmental Committee on Compensation for Industrial Diseases by the National Society of Amalgamated Brass Workers,[1] including about 7,000 members, it was stated that about 2,000 of these were engaged in casting. The trade was said to be divided into pattern making, chasing, casting, finishing, burnishing, polishing, and putting together. The corresponding classification of the trade in the United States follows practically similar lines.[2] Of the divisions mentioned, casting and founding were considered the most injurious to health. Burnishing was held to be less injurious than polishing, but the so-called putting together was stated to be decidedly unhealthful on account of the use of white lead. Evidently, in so diversified a trade the degree of dust exposure must vary widely, and at best the degree of injury can only be measured approximately upon the basis of more or less indefinite mortality data. The exposure of brass workers to dust inhalation is only one of a number of specific factors in a trade decidedly injurious to health and life, and of these mention may be made of the exposure to fumes and vapors generated in the smelting processes. Brass founders' ague is a well-defined occupational disease, the symptoms of which are tightness of the chest with indefinite nervous sensation, followed by fever and previous sweating. Zinc and other fumes inhaled are the chief causes of this ailment, and it is quite probable that the lung injury resulting from the inhalation of fine particles of metallic dust is a material contributory cause in brass founder's ague. Arlidge, in summing up the views of other authorities on brass workers' disease, points out that—

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[1] Great Britain, Home Department, Minutes of Evidence, Departmental Committee on Compensation for Industrial Diseases, 1906, p. 75 et seq.

[2] The number of brass workers in the United States in 1910 was 46,722, and of this number 3,062 were women.

> Besides brass founding, there are other departments in the brass-working business that are damaging to health; and chiefly so by reason of the dust produced. These branches are brass casting, turning, filing, and polishing. The soft nature of brass is opposed to the development of very fine and acuminated particles, and its weight to its rising very freely and to its diffusion in the air. Nevertheless, those turning and filing it show clearly, by their clothes and hair, that it is largely dispersed, the latter getting green, as happens with brass founders. The inhalation of brass dust operates in similar fashion to that seen in connection with other metallic dusts, provoking bronchial catarrh, which advances to bronchitis and ends in fibrosis. It is reported by some writers that phthisis is unusually prevalent, but no reliable statistics are available to support this statement.

SANITARY CONDITIONS IN THE BRITISH BRASS INDUSTRY.

More recent investigations in England fully confirm these earlier conclusions. In 1894 a departmental committee was appointed by the secretary of state to report upon the conditions of work as affecting the health of operatives in the manufacture of brass and kindred amalgams. In its report, which was published in 1896, the committee stated as the result of its investigation, first, that brass workers as a class were extremely liable to diseases of the respiratory organs, and, second, that brass founders' ague, so called, was found to result from the inhalation of fumes given off by the molten brass at the time of pouring, but in a less degree it was attributed to the contamination of the workers' food by the fumes, and that this danger was in proportion to the amount of zinc used in the alloy. The subject was also reported upon in much detail in the Report of the Chief Inspector of Factories and Workshops for the year 1905. From this report the following suggestive extracts are made:

> Altogether some 500 brass workers were examined, and in addition to the filling in by each one of them of the appended form, note was made of the height, weight, chest measurement, and strength of grasp; the heart, lungs, gums, and teeth were, whenever practicable, examined, and the condition as to anemia, paresis, general health, and prevalence of brass founders' ague was determined.
>
> The result of the replies of 216 casters and 199 polishers and others to the question, Do you consider that your health has been in any way injured by working in brass? was that 22.7 per cent of the casters and 11.6 per cent of the polishers and others said they had suffered. This is perhaps the strongest evidence obtained in the inquiry that the casters are exposed to more trying conditions of work than are other brass workers.
>
> The nature of the injury was, as a rule, only very vaguely expressed; in the case of the casters it was nearly always either "fumes" or "sulphur," and in that of the polishers "dust." In one casting shop, where 19 strip casters were examined, of whom 9 said they suffered, illness or discomfort was attributed in some cases to resin fumes in addition to those ordinarily present. Among the casters there were indications that the older the workers were, and also that the earlier the age of commencement of work, the more did they say they had suffered, facts which could not be observed in the case of the polishers.
>
> In 8 casters (3.9 per cent) definite physical signs in the lungs were found, and similarly in 3 (1.5 per cent) of the polishers and others. In two of the casters these pointed to chronic phthisis, while the remainder pointed to bronchial catarrh. I am not inclined to draw any conclusions from these facts, because (1) the number of observations is too small, (2) the examination in some of the factories was carried out under great disadvantages, owing to the impossibility of securing a quiet room, and (3) it is well known that persons who are the subjects of disease of the lungs in any marked degree are not likely to be found at work.
>
> Very strong evidence of the beneficial effect of good exhaust ventilation in connection with all kinds of polishing operations, and indirectly of the lowered state of health from the nonremoval of the dust, was obtained at one factory. Here the opinion of the occupier was that the installation had paid for itself over and over again in the better work which was turned out by the men, and by the improved tone among them resulting from the absence of the obnoxious dust. The remarks of the polishers bore this out. One said, "Worked for 18 years before the fan was put in, when the dust used to make me feel sick, but it is not so now." A second said, "I prefer this shop to any other." A third, "I never worked in a cleaner shop"; and a fourth, "The fan is a great improvement."
>
> A large amount of fluff, sand, and lime is given off in the process of polishing with calico mops. It is not, therefore, difficult to understand (even although actual injury to health from it may be hard to prove) that removal of the dust is welcomed as tending to make the work healthier. A sample of dust taken from under a polishing bob was submitted to Dr. Thorpe, who reported: "This sample con-

tains a large proportion of fiber, the loss on ignition amounting to 37.6 per cent. The metallic portion of the residue—copper, zinc, lead, and iron—amounts to 10.56 per cent of the total sample. The lead present equals 0.22 per cent of the total samples, or 2.1 per cent of the above metallic constituents, or, excluding the iron, 2.33 per cent. Microscopically brass dust collected from near an emery wheel showed all the appearances of an injurious metallic dust—fine particles with irregular jagged edges."

Oliver concludes his observations regarding the hygiene of this employment with the following statement:

> The necessity of personal cleanliness on the part of workmen and of well-ventilated workshops is apparent. Means ought to be provided for a ready escape of the fumes and for the removal of dust. The workshops ought to be cleaned at least once a year and the walls whitewashed. Hot and cold water should be provided for the men to wash in. The workmen themselves have found out by experience that milk is both a prophylactic or preventive as well as a curative agent. While the use of respirators seems called for, the men can not work well in them. Women and persons under 18 years of age are not allowed to work in the casting shop.

ENGLISH MORTALITY STATISTICS OF BRASS WORKERS.

The most recent English mortality statistics of brass workers are for the three years ending with 1902, referred to in the report of the registrar general, in part, as follows:

> The mortality of these workers is somewhat below the standard at ages 15 to 20 and 25 to 35 years, but above the standard at every other age group. In the main working period of life their comparative mortality figure is 1,154, or 15 per cent above the average; the greatest excess of mortality occurring under the head of phthisis, the figure for which disease is above the average by 45 per cent. The mortality from diseases of the nervous, circulatory, respiratory, and urinary systems, as well as from suicide is also above the average. These workers are only slightly liable to fatal influenza, and their mortality from alcoholism and liver disease is also low. They likewise suffer less than the average from fatal accident.[1]

The English occupation mortality statistics for brass workers are quite conclusive of the more or less unfavorable effects of this industry on health. In Table 57 a comparison is made of the mortality from all causes of men in this group with occupied males generally, and the result is quite suggestive of conditions in this trade more or less unfavorable to life and health, but in particular at ages 35 to 64, when the general mortality of this class exceeds the general average by from 2.57 to 5.59 per 1,000.

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[1] Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales, p. lxxv.

TABLE 57.—MORTALITY FROM ALL CAUSES OF BRASS WORKERS, COMPARED WITH THAT OF ALL OCCUPIED MALES, IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[Source: Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 for all occupied males.	Death rate for brass workers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Per cent of rate for all occupied males.
15 to 19 years	2.44	2.22	−0.22	91
20 to 24 years	4.41	5.13	+ .72	116
25 to 34 years	6.01	5.86	− .15	98
35 to 44 years	10.22	12.79	+2.57	125
45 to 54 years	17.73	20.90	+3.17	118
55 to 64 years	31.01	36.60	+5.59	118
65 years and over	88.39	83.78	−4.61	95

The preceding table is self-explanatory. A more extended comparison is made in Table 58, in which the mortality of brass workers from pulmonary tuberculosis and respiratory diseases other than tuberculosis is compared with the normal mortality of occupied males from these diseases by divisional periods of life. The comparison shows that at ages 20 to 64, inclusive, the mortality of brass workers from pulmonary tuberculosis is excessive by from 0.42 to 1.79 per 1,000, the excess being greatest at ages 35 to 44. The table further shows that the mortality from respiratory diseases other than tuberculosis is excessive among men in this class, but decidedly so at ages 55 and over, when the excess is from 1.29 to 2.88 per 1,000. The two tables derived from English experience fully confirm the previous conclusion that the mortality of brass workers is excessive when comparison is made with the normal mortality of occupied males generally, and that this excess is largely because of the high degree of tuberculosis frequency, particularly at ages 25 to 54.[1]

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[1] An excellent account of the comparative social and health conditions of brassworkers, entitled "Brassworkers of Berlin and of Birmingham," was published by P. S. King & Son, London, in 1910. This is a joint report by a representative of a large brassworks, the secretary of the National Society of Amalgamated Brassworkers, and a representative of the Birmingham Hospital. The report includes an interesting account of the Brassworkers' Trade Union and general observations on the German compulsory health insurance system.

TABLE 58.—MORTALITY FROM PULMONARY TUBERCULOSIS AND FROM OTHER DISEASES OF THE RESPIRATORY SYSTEM AMONG BRASS WORKERS, COMPARED WITH THAT OF ALL OCCUPIED MALES, IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[Source: Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Mortality from pulmonary tuberculosis.				Mortality from other diseases of the respiratory system.			
	Death rate per 1,000 for all occupied males.	Death rate for brass workers.			Death rate per 1,000 for all occupied males.	Death rate for brass workers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Per cent of rate for all occupied males.		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Per cent of rate for all occupied males.
15 to 19 years	0.54	0.49	−0.05	91	0.24	0.24	....	100
20 to 24 years	1.55	2.17	+ .62	140	.48	.52	+0.04	108
25 to 34 years	2.03	2.93	+ .90	144	.77	.60	− .17	78
35 to 44 years	2.74	4.53	+1.79	165	1.66	2.05	+ .39	123
45 to 54 years	3.04	4.61	+1.57	152	3.32	3.94	+ .62	119
55 to 64 years	2.16	2.58	+ .42	119	6.54	9.42	+2.88	144
65 years and over	1.11	.44	− .67	40	17.77	19.06	+1.29	107

INVESTIGATIONS BY THE ILLINOIS COMMISSION ON OCCUPATIONAL DISEASES.

A number of special investigations have been made of the brass industry in the United States, but chiefly with reference to the occurrence of brass poisoning, or "brass founders' ague." One of the most important of these investigations is by E. R. Hayhurst, the results of which were published by the Illinois Commission on Occupational Diseases. Brass being an alloy composed of copper and zinc, the actual degree of metallic dust exposure in the different processes is quite considerable. No specialized investigations have been made to ascertain the relative degree of dust exposure at the furnaces and the foundries and in connection with manufacturing processes. The dust inhaled is, of course, more or less mixed, and in the majority of cases may be more mineral than metallic in character. The so-called "brass chills," or "brass founders' ague," occurs almost exclusively in brass foundries and never in the more specialized manufacturing processes. According to Hayhurst, however, in addition to brass founders' ague there is a distinct liability to respiratory diseases.

MORTALITY OF BRASS MOLDERS IN OHIO.

An investigation made in Ohio for the three years, 1910 to 1912, included 43 deaths of brass molders and brass workers, of whom 14, or 32.7 per cent, died from pulmonary tuberculosis. It is pointed out in this connection in Hayhurst's report on Health Hazards that "While the number of total deaths reported is small, the high rate of consumption is in harmony with observations concerning this industry reported elsewhere." Old age is rarely attained among persons employed in the brass industry, and, according to Sir Thomas Oliver, out of 1,200 brass casters in Birmingham (England) only 10 were found to be living beyond 60 years. How far this inferior longevity is the result of dust exposure is not, perhaps, directly ascertainable, but there are reasons for believing that the excessive mortality from tuberculous diseases among brass workers bears some relation to the relatively considerable and practically continuous exposure to metallic and mineral dust.

This exposure, of course, is exceptionally great in grinding and polishing brass, which are elsewhere discussed in detail without particular reference, however, to the brass industry. The sanitary conditions of the industry are, as a general rule, far from satisfactory, and in the Ohio investigation, for illustration, "in no place were means adopted to confine and remove brass fumes during pouring." The general construction of brass foundries was determined as hygienically good in 42 places, fairly so in 21, and unsatisfactory in the remaining 43. All of the special processes, such as core making, metal grinding, casting cleaning, machine-shop practice, polishing and buffing, involve a more or less definite hazard of dust exposure. The air conditions in the foundry processes of the brass-working plants investigated in Ohio were found to be good in only 17 places, fair in 41, and decidedly hazardous to the health of the workers in 48.

MEDICAL ASPECTS OF THE BRASS INDUSTRY IN CONNECTICUT.

The medical aspects of the brass industry in Connecticut have been investigated and reported upon by W. Gilman Thompson, who states that:

> The inhalation of powdered brass, the dust of brass filings, etc., irritates the respiratory mucosa and lungs. The metal may also be swallowed after inhalation into the mouth, or conveyance to the mouth by unclean hands or food or plug tobacco. In this manner chronic poisoning in time results, with symptoms which differ considerably from those of the ague, above described. Chronic bronchitis is usually to be found and sometimes fibroid phthisis and tuberculosis. The digestive system is deranged, and the victim complains of dyspepsia, anorexia, gastro-intestinal catarrh, nausea, vomiting, thirst, irregular action of the bowels, occasional intestinal colic, and a metallic taste in the mouth. The tartar on the teeth may become green from a deposit of copper salts. Headache and general muscular pains are common, and the patients often become neurotic, depressed, and hypochondriacal.

The evidence obtainable by means of such investigations would, therefore, seem to sustain the statistical data derived from American and foreign sources.

MORTALITY OF BRASS WORKERS—UNITED STATES REGISTRATION AREA.

The mortality of brass workers has been reported upon for the year 1909 by the Division of Vital Statistics of the United States Census Bureau, but no subsequent information has been made public, and the data are, therefore, limited to the year referred to. According to the census report, out of 201 deaths of brass workers, 64, or 31.8 per cent, were from pulmonary tuberculosis. The details of the mortality by age groups are shown in Table 59.

TABLE 59.—PROPORTIONATE MORTALITY OF BRASS WORKERS FROM PULMONARY TUBERCULOSIS, UNITED STATES REGISTRATION AREA, 1909, BY AGE GROUPS.

Age at death.	Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent of deaths from all causes.
15 to 24 years	25	16	64.0
25 to 34 years	42	21	50.0
35 to 44 years	35	11	31.4
45 to 54 years	48	8	16.7
55 to 64 years	26	4	15.4
65 years and over	25	4	16.0
Total, 15 years and over	201	64	31.8

TABLE 60.—PROPORTIONATE MORTALITY OF BRASS WORKERS FROM NONTUBERCULOUS RESPIRATORY DISEASES, UNITED STATES REGISTRATION AREA, 1909.

Cause of death.	Deaths from nontuberculous respiratory diseases.	
	Number.	Per cent of deaths from all causes.
Asthma		
Bronchitis	3	1.5
Pneumonia	18	9.0
Other nontuberculous respiratory diseases	1	.5
Total	22	10.9

Table 59 is extremely suggestive and indicates an excessive frequency of pulmonary tuberculosis among brass workers, which term unquestionably includes a considerable number of polishers and buffers. Aside from the relatively high proportion of deaths from pulmonary tuberculosis of 31.8 per cent in the mortality from all causes, other nontuberculous respiratory diseases as shown in Table 60 cause a mortality of 10.9 per cent, or, respectively, 1.5 per cent from bronchitis, 9 per cent from pneumonia, and 0.5 per cent from other respiratory diseases. The table in a general way confirms the data derived from other sources, and obviously suggests the relative unhealthfulness of employment in the brass industries, without specific reference, however, to the particular occupations, as to which the information is not available.

The results of this analysis of the available American vital statistics of brass workers for the registration area are further confirmed by the corresponding statistics derived from the industrial insurance experience of the Prudential Insurance Co.

MORTALITY OF BRASS WORKERS—INDUSTRIAL INSURANCE EXPERIENCE.

TABLE 61.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG BRASS WORKERS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, COMPARED WITH THAT OF ALL MALES IN UNITED STATES REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of brass workers, 1897 to 1914, from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Brass workers.	Males in the registration area, 1900 to 1913.
15 to 24 years	91	53	58.2	27.0
25 to 34 years	149	76	51.0	30.5
35 to 44 years	146	64	43.8	23.4
45 to 54 years	99	24	24.2	14.7
55 to 64 years	93	15	16.1	7.9
65 years and over	55			2.6
Total, 15 years and over	633	232	36.7	13.9

The experience shown in Table 61 includes 633 deaths from all causes, of which 232, or 36.7 per cent, are from pulmonary tuberculosis. The proportionate mortality from pulmonary tuberculosis is decidedly excessive at all ages under 65. In support of the statistics quoted by Sir Thomas Oliver regarding the proportion of brass workers attaining to old age, it is suggestive that out of 633 deaths of brass workers at all ages, 55, or only 8.7 per cent, should have attained to ages 65 and over. The statistics of Sir Thomas Oliver, however, apparently have reference to brass founders alone, who are unquestionably exposed to greater health hazards than brass workers generally. Unfortunately the data for a specialized analysis by occupations, in detail, are not available for the brass industry at the present time.

GENERAL CONCLUSIONS.

In a general way the insurance mortality statistics confirm the data and observations derived from other sources. The dust hazard in the brass working trade is, of course, only one of many health-injurious conditions inherent in the industry, all of which are suggestive of the exceptional urgency of thoroughly efficient sanitary precautions, and the use of protective devices on the part of those most seriously affected by the liability to brass poisoning and its related respiratory affections.

ARTIFICIAL FLOWERS.

This occupation is not strictly within the group of trades, industries, or occupations with continuous and considerable exposure to metallic dust. It is, however, included in view of the observations by Sir Thomas Oliver, that the workers employed in the manufacture of artificial flowers, chiefly French roses, especially the double roses, "complain of headache, nasal catarrh, dryness of the throat, probably from the dust, and also of vomiting." In addition, he observes, "In at least one-third of those who suffer, the symptoms are those of metallic poisoning, for on examination of the red leaves of the roses several are found to contain salts of lead." He draws particular attention to the health-injurious effects of this group of occupations upon the young women engaged in salesrooms where artificial flowers are collected and distributed, and states that "a few of them show a tendency to laryngeal and pulmonary catarrh, attended by a cough, owing to the dust given off by the flowers. Upon a microscopic examination of the expectoration it was found that particles of dust contained therein were identical with those given off from the flowers."

PROCESSES OF ARTIFICIAL-FLOWER MAKING.

An extended account of the processes of artificial-flower making in the United States, by Walter O. Lincoln, is published in the Weekly Underwriter, New York, March 17, 1914. The different processes are not indicative of a considerable amount of dust exposure, although mention is made of the use of tinsel including mica in its composition. In connection with the manufacture of leaves it is stated that the claim is made on good authority that "the gas-heated presses are injurious to the health of the operators, who are required to sit many hours with the lower limbs extended under the press, with gas burners near by, which overheat the abdomen and cause stomach trouble." There are, however, no intimations that the manufacture of leaves or flowers involves a particular hazard of metallic or mineral dust exposure.

A brief reference occurs in the Second Report of the New York State Factory Investigating Commission (Vol. II, p. 1156), according to which "The danger in this industry was reputed to be from the use of the arsenic greens for the purpose of dyeing and dusting the material." The different processes are briefly described in the preliminary report of the commission for 1912. In none of these investigations was definite evidence produced tending to prove an exceptional liability to pulmonary tuberculosis in consequence of exposure to the inhalation of metallic and mineral dusts, but more extended investigations would be required for the purpose of scientific conclusiveness.

An admirable discussion of the life and labor of artificial-flower workers by Miss Mary Van Kleeck was published by the Russell Sage Foundation in behalf of the Committee on Women's Work (New York, 1913). The investigation is of special importance in view of the fact that it was made in the city of New York where three-quarters of all the artificial flowers produced in the United States are made. All of the shops in the Borough of Manhattan known to make artificial flowers, employing 5,240 workers, were visited. The proportions in various age groups of 371 home workers in 110 families were as follows: Children under 8 years of age, 10.2 per cent; children 8 to 14 years of age, 27.2 per cent; children 14 to 16 years of age, 11.3 per cent; and adults 16 years of age and over, 51.3 per cent. The proportions in various age groups of women shop workers employed in artificial-flower making were: Ages 10 to 16 years, 14 per cent; ages 16 to 25 years, 63 per cent; and ages 25 and over, 23 per cent. This compares with all women workers in manufacturing industries as follows: Ages 10 to 16 years, 9 per cent; ages 16 to 25, 53 per cent; and ages 25 years and over, 38 per cent. The artificial-flower making industry is, therefore, typically representative of female workers at the younger or immature ages. An analysis of the wages earned proves conclusively that the employments are decidedly underpaid. An inquiry into the hours with special reference to fatigue seemed to justify the conclusion that, regardless of the fact that the work was light, the elements of fatigue were by no means lacking; that many of the workrooms were poorly ventilated, and that the air was vitiated because of the use of gas stoves for heating the tools and sometimes by gas used in illumination. Complaint was also made that certain dyes used were poisonous, and, according to the author, "this opinion was expressed so frequently by the workers that it seems credible, although no medical examinations have been made to support it. The girls say that they inhale the dust from cheap flowers and that the color frequently stains their hands and may inadvertently be rubbed on the mouth or eyes." It is, therefore, suggested that "a special investigation of the physical effects of these dyes ought to be made, but in the broader sense the health aspects of the entire industry should be subjected to critical and qualified consideration."

GENERAL CONCLUSIONS.

Since in this industry women are almost exclusively employed, the industrial insurance experience data are inconclusive. There have been only 13 deaths of male artificial-flower makers in the experience of the Prudential Insurance Co. during the period 1907 to 1914, of which, however, 4, or 30.8 per cent, were from pulmonary tuberculosis. Three of the deaths occurred at ages under 35, of which two were from this particular disease. The corresponding data for women are not available. On account of its practical importance as an employment for young persons, chiefly girls of the period of early adolescence, it would seem a matter of some urgency that the health aspect of this group of occupations with special reference to the dust hazard and the probable liability to an excessive mortality from tuberculosis should be made the subject of a thoroughly qualified investigation.

CHAPTER III.—OCCUPATIONS WITH EXPOSURE TO MINERAL DUST.

Mineral-dust exposure is most common in the stone industry, among potters, in cement manufacture, and in mining. Mineral dust varies widely and essentially in its mechanical and chemical properties, and much more so than is the case with the different varieties of metallic dust. The quantitative degree of dust exposure is also decidedly greater in the case of mineral dust, which frequently contaminates the entire atmosphere in a finely comminuted form for prolonged periods of time. Since all dust is primarily injurious on account of its irritating effects on the respiratory organs, it is self-evident that essential variation in the mechanical properties of the dust must correspondingly affect the consequential results on lung tissue and the development of lung fibrosis and pulmonary tuberculosis. It is estimated that at every inhalation an adult person inhales about one-half liter of air, and since the normal respiration is from 16 to 18 times per minute the approximate quantity of air inhaled is from 8 to 9 liters per minute and from 480 to 540 liters per hour. Continuous exposure, therefore, to even relatively small amounts of atmospheric impurities may have proportionately serious pathological results. According to Hesse, a man working 10 hours a day inhales approximately 0.09 gram of dust per day if employed in a sawmill, 0.025 gram per day if employed in a flour mill, and 1.12 grams per day if employed in a cement mill. Regardless, however, of the fact that the quantitative exposure to dust inhalation in cement manufacture exceeds very considerably the corresponding exposure in many other occupations, it is apparently well established by reasonably trustworthy data that the inhalation of cement dust is decidedly less injurious to lung tissue, with special reference to pulmonary tuberculosis, than exposure to sandstone dust or granite dust, etc. One important factor which is frequently overlooked is the solubility or insolubility of the mineral dust inhaled, and the chemical nature of the dust may therefore be of even greater importance than its mechanically irritating qualities. The degree of comminution is also of material importance in that in almost exact proportion to the degree of fineness the dust particles will penetrate into the remote portions of the lungs. It is therefore held that the more minutely comminuted the dust, the more serious, in general terms, will be the damage to the respiratory organs.

MINERAL DUST AND PULMONARY TUBERCULOSIS.

The term "mineral dust" for practical reasons is, for the present purpose, limited to finely comminuted particles of mineral substances as generally differentiated from metallic substances obtained by mining, quarrying, or other extractive processes. No precise definition regarding mineral dust seems practicable in view of the truly enormous range of minerals, varying from potash salts and fuller's earth, phosphate rock, mica, slate, asbestos, mineral paints, graphite, cement, gypsum, borax, asphalt, lime, coke, etc., to pure silica or quartz, which for the present purpose must be considered the most injurious of all forms of mineral dust, approaching quite closely in degree of seriousness to the most irritating forms of metallic dust. The relation of mineral-dust inhalation to pulmonary tuberculosis and nontuberculous lung diseases is ascertainable only as regards the more important mineral products, such as slate, cement, lime, coal, silica, and other stones, chiefly marble, limestone, sandstone, bluestone, and granite. There are no trustworthy mortality statistics regarding dust exposure and its relation to health in connection with the mining of phosphate rock, mica, asbestos, sulphur, soapstone, graphite, borax, asphalt, and abrasive materials. Few of these industries are relatively important as regards the number of persons employed therein, but for scientific purposes it is most desirable that the health-injurious results of each and every form of mineral dust should receive the required extended and qualified consideration. The typical form of industrial-dust phthisis met with in occupations with exposure to mineral dust conforms more to the precise definition of industrial pneumoconiosis or nontuberculous lung disease in its initial development, although as a general rule there is a superinduced true pulmonary tuberculosis which is properly returned as the immediate cause of death. In occupations with exposure to mineral dust it is therefore of even greater importance than in occupations with exposure to metallic dust that the nontuberculous lung diseases, particularly asthma and chronic bronchitis, should receive some consideration, aside from the invariably more important mortality from pulmonary tuberculosis, although the latter often is not the primary but rather a contributory cause of death.

LUNG DISEASES AND MINERAL AND METALLIC DUST EXPOSURE.

This conclusion is quite fully sustained by Table 62, which is derived from the industrial insurance experience of the Prudential Insurance Co. for the period 1897 to 1914, and which may safely be considered representative for the country at large.

TABLE 62.—COMPARATIVE PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AND NONTUBERCULOUS RESPIRATORY DISEASES IN OCCUPATIONS EXPOSING TO MINERAL AND METALLIC DUST, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914.

Cause of death.	Deaths of workers exposed to—			
	Mineral dust.		Metallic dust.	
	Number.	Per cent.	Number.	Per cent.
Pulmonary tuberculosis	3,129	27.3	2,960	36.0
Asthma	105	.9	47	.6
Bronchitis	173	1.5	70	.9
Pneumonia	1,198	10.5	696	8.5
Other nontuberculous respiratory diseases	199	1.7	132	1.6
Total	1,675	14.6	945	11.5
All other causes	6,653	58.1	4,326	52.5
Total, all causes	11,457	100.0	8,231	100.0

According to this analysis the proportionate mortality from nontuberculous respiratory diseases in occupations with exposure to mineral dust is 14.6 per cent, against 11.5 per cent for occupations with exposure to metallic dust. Every important form of nontuberculous respiratory disease is proportionately more common among occupations with exposure to mineral dust, but the proportionate mortality from pulmonary tuberculosis is only 27.3 per cent, against 36 per cent for occupations with exposure to metallic dust.

MORTALITY FROM PULMONARY TUBERCULOSIS IN OCCUPATIONS WITH EXPOSURE TO MINERAL DUSTS—UNITED STATES REGISTRATION AREA.

The conditions of employment in the industries, trades, and occupations which are considered in detail in this chapter are often so widely at variance with one another that, as stated in the preceding chapter with regard to metallic dust, the mortality data represent averages which must be interpreted with extreme caution as regards their application to particular employments with a more or less ascertainable degree of exposure to mineral dust. Such exposure is nearly always an important predisposing cause of pulmonary tuberculosis, but particularly so in certain branches of the stone industry and among potters. Tables 63 and 64 following are, therefore, merely intended as a general statement of the essential mortality facts concerning this group of occupations, with special reference to pulmonary tuberculosis and nontuberculous respiratory diseases, as derived from the available official statistics of the Division of Vital Statistics of the United States Census Bureau. A subsequent additional table presents the corresponding facts as derived from the extended experience of a representative industrial insurance company. The practical usefulness of this analysis is naturally rather limited for the reasons stated, but the data provide a fairly trustworthy measure of the relative frequency of pulmonary tuberculosis in the group of industries and occupations subject to a more or less ascertainable degree of health-injurious exposure to the continuous and considerable inhalation of mineral dust.

TABLE 63.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS IN OCCUPATIONS WITH EXPOSURE TO MINERAL DUST, UNITED STATES REGISTRATION AREA, 1908 AND 1909, BY AGE GROUPS.

Age at death.	Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent of deaths from all causes.
15 to 24 years	756	256	33.9
25 to 34 years	1,524	582	38.2
35 to 44 years	2,172	700	32.2
45 to 54 years	2,399	523	21.8
55 to 64 years	2,258	259	11.5
65 years and over	2,162	87	4.0
Age unknown	10	1	10.0
Total, 15 years and over	11,281	2,408	21.3

TABLE 64.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES IN OCCUPATIONS WITH EXPOSURE TO MINERAL DUST, UNITED STATES REGISTRATION AREA, 1908 AND 1909.

Cause of death.	Number of deaths.	Per cent of deaths from all causes.
Asthma	26	0.2
Bronchitis	96	.9
Pneumonia	840	7.4
Other nontuberculous respiratory diseases	124	1.1
Total	1,086	9.6

INCONCLUSIVE OCCUPATIONAL MORTALITY STATISTICS.

The aggregate experience, according to Table 63, for the two years under observation (no subsequent official statistics have been published), indicates a proportionate mortality from pulmonary tuberculosis among men employed in occupations with exposure to mineral dust of 21.3 per cent, which compares with 21 per cent for occupations with exposure to metallic dust, as ascertained by an analysis of the corresponding data derived from the same official sources. The data can not be considered entirely conclusive on account of the fact that the industries and occupations with exposure to mineral dust include a relatively large number of persons not exposed to the risk of dust inhalation to a serious degree. If it were practicable to separate those directly exposed to the dust danger from those not exposed to any such risk whatever, the resulting proportionate mortality from pulmonary tuberculosis and nontuberculous respiratory diseases would, of course, be much more excessive. For illustration, it is noted that the pottery industry as a whole is chargeable with a serious risk of mineral-dust exposure. The particular dust hazard is experienced chiefly among flint-mill workers, mixers, scourers, and sweepers. If the mortality rate of these employments could be correctly ascertained with particular reference to pulmonary tuberculosis, there can be no question of doubt that the proportionate mortality figure would be decidedly in excess of the corresponding figure for jiggermen, jollymen, throwers, and other numerically important pottery employees. The same conclusion applies to the glass industry, where the handlers of materials and mixers are exposed to a readily ascertainable dust hazard, which to a lesser degree affects batch wheelers, carboy blowers, clay grinders, clay trampers, gatherers, pot makers, etc., and to a still lesser degree, glass blowers, finishers, lamp workers, pressers, etc. As far as possible the occupational differences in particular industries are considered in detail in the discussion following, but it has seemed advisable to consolidate the available data for the purpose of ascertaining, as far as practicable, the general effect of mineral-dust exposure, which, as previously observed, appears to be less serious with reference to pulmonary tuberculosis than continuous and considerable exposure to metallic dust.

COMPARATIVE MORTALITY BY INDUSTRIES OR OCCUPATIONS.

In addition to the mortality from pulmonary tuberculosis the comparative mortality from nontuberculous respiratory diseases, particularly asthma and bronchitis, is also distinctly excessive among occupations with exposure to mineral dust, and even more so than among the corresponding occupations with exposure to metallic dust. The details of the proportionate mortality from pulmonary tuberculosis in the principal occupations for which the information is ascertainable from the reports of the Division of Vital Statistics of the United States Census Bureau, for the two years 1908 and 1909, are, for purposes of convenience, shown in Table 65.

TABLE 65.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS IN SPECIFIED INDUSTRIES OR OCCUPATIONS WITH EXPOSURE TO MINERAL DUST, UNITED STATES REGISTRATION AREA, 1908 AND 1909, BY AGE GROUPS.

Occupation group.	15 to 24 years.			25 to 34 years.			35 to 44 years.			45 to 54 years.		
	Deaths from all causes.	Deaths from pulmonary tuberculosis.		Deaths from all causes.	Deaths from pulmonary tuberculosis.		Deaths from all causes.	Deaths from pulmonary tuberculosis.		Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent.		Number.	Per cent.		Number.	Per cent.		Number.	Per cent.
Brick and tile makers[1]	14	3	21.4	13	3	23.1	18	5	27.8	20	3	15.0
Glassworkers	176	83	47.2	202	86	42.6	169	56	33.1	117	23	19.7
Marble and stone cutters	61	16	26.2	170	74	43.5	299	132	44.1	401	167	41.6
Painters, glaziers, and varnishers	429	132	30.8	968	357	36.9	1,423	415	29.2	1,598	278	17.4
Paper hangers[1]	15	4	26.7	36	16	44.4	60	20	33.3	42	9	21.4
Plasterers	48	12	25.0	108	34	31.5	177	61	34.5	189	31	16.4
Potters[1]	13	6	46.2	27	12	44.4	26	11	42.3	32	12	37.5
Total	756	256	33.9	1,524	582	38.2	2,172	700	32.2	2,399	523	21.8

Occupation group.	55 to 64 years.			65 years and over.			Age unknown.			Total, 15 years and over.		
Brick and tile makers[1]	26	2	7.7	41	......	.....	1	......	.....	133	16	12.0
Glassworkers	101	8	7.9	101	4	4.0	1	......	.....	867	260	30.0
Marble and stone cutters	407	95	23.3	316	25	7.9	3	......	.....	1,657	509	30.7
Painters, glaziers, and varnishers	1,474	132	9.0	1,398	46	3.3	4	1	25.0	7,294	1,361	18.7
Paper hangers[1]	33	1	3.0	31	2	6.5	....	......	.....	217	52	24.0
Plasterers	205	16	7.8	249	9	3.6	1	......	.....	977	163	16.7
Potters[1]	12	5	41.7	26	1	3.8	....	......	.....	136	47	34.6
Total	2,258	259	11.5	2,162	87	4.0	10	1	10.0	11,281	2,408	21.3

[1] Data are for 1909 only.

The table emphasizes the rather wide range in the mortality from pulmonary tuberculosis in the different occupations, industries, or trades with exposure to mineral dust, a difference attributable partly at least to variations in conditions of employment, or, more precisely, to the proportion of all the employees of the industry concerned who were considerably exposed to the dust menace. A much more important influence, however, on the tuberculosis rate is the variation in the chemical and mechanical properties of the mineral dust inhaled and the quantitative degree of dust inhaled, which, as elsewhere observed, probably reaches a maximum in certain processes of cement manufacture. The statistics for the United States registration area are unfortunately limited to a comparatively small number of specified industries and trades, but there are no reasons for believing that the proportionate mortality figure would be materially modified by the inclusion of similar or allied employments or occupations for which the information is at present not ascertainable from official sources. The comparison of the different employments one with another is also subject to the further restriction, as regards practical usefulness, that while for some industries and occupations, such, for illustration, as painters, etc., the number of deaths is relatively large and sufficient for the purpose, for other occupations, such, for illustration, as brick and tile making and the pottery industry, the number of deaths is too limited for entirely safe conclusions.

MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES.

The limitations of the available statistics are even more serious in the case of nontuberculous respiratory diseases, but it has seemed advisable for the present purpose to include Table 66, which, however, gives data which refers only to all ages combined and not to divisional periods of life on account of the relatively small number of deaths available for analysis.

TABLE 66.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES IN SPECIFIED INDUSTRIES OR OCCUPATIONS WITH EXPOSURE TO MINERAL DUST, UNITED STATES REGISTRATION AREA, 1908 AND 1909.

Occupation group.	Deaths caused by nontuberculous respiratory diseases.									
	Asthma.		Bronchitis.		Pneumonia.		Other.		Total.	
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
Brick and tile makers [1]	......	......	......	......	8	6.0	2	1.5	10	7.5
Glassworkers	2	0.2	5	0.6	67	7.7	6	.7	80	9.2
Marble and stone cutters	9	.5	29	1.8	131	7.9	33	2.0	202	12.2
Painters, glaziers, and varnishers	11	.2	47	.6	533	7.3	64	.9	655	9.0
Paper hangers [1]	......	......	3	1.4	13	6.0	2	.9	18	8.3
Plasterers	3	.3	11	1.1	79	8.1	11	1.1	104	10.6
Potters [1]	1	.7	1	.7	9	6.7	6	4.4	17	12.5
Total	26	.2	96	.9	840	7.4	124	1.1	1,086	9.6

[1] Data are for 1909 only.

INDUSTRIAL INSURANCE MORTALITY EXPERIENCE.

In view of the limited extent of the available official occupation mortality statistics of the registration area, the industrial mortality experience of the Prudential Insurance Co. of America is somewhat more conclusive, in that the number of specific occupations is more representative of the industries and employments with exposure to mineral dust. When considered as a group and for some of the more important occupations, the actual mortality data are also more extensive. The details of the experience are set forth in Table 67.

TABLE 67.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS IN OCCUPATIONS WITH EXPOSURE TO MINERAL DUST, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914.

Age at death.	Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent of deaths from all causes.
15 to 24 years	1,141	365	32.0
25 to 34 years	1,920	875	45.6
35 to 44 years	2,280	823	36.1
45 to 54 years	2,303	602	26.1
55 to 64 years	2,127	355	16.7
65 years and over	1,684	109	6.5
Age unknown	2	....	....
Total, 15 years and over	11,457	3,129	27.3

TABLE 68.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES IN OCCUPATIONS WITH EXPOSURE TO MINERAL DUST, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 to 1914.

Cause of death.	Number of deaths.	Per cent of deaths from all causes.
Asthma	105	0.9
Bronchitis	173	1.5
Pneumonia	1,198	10.5
Other nontuberculous respiratory diseases	199	1.7
Total	1,675	14.6

As observed in connection with the corresponding discussion of the occupations with exposure to metallic dust, the insurance experience is not strictly comparable with the general mortality for the country at large, for the principle of adverse selection must be considered, and the fact that only a small proportion of the risks accepted for industrial insurance are at entry subjected to a thorough medical examination. A much more important factor, however, is that the occupation analysis in the Prudential Co. experience is more strictly limited to specific occupations with mineral-dust exposure as separate and distinct from industries or groups of closely allied employments, which it is safe to assume are more representative of the census mortality returns; in other words, in the Prudential mortality experience the reference is rather to potters than to men employed in the pottery industry; to glassworkers rather than to men employed in the glass industry; more so than is the case in the returns made available through the Division of Vital Statistics of the United States Census Bureau for the two years 1908 and 1909.

EXCESSIVE FREQUENCY OF PULMONARY TUBERCULOSIS.

According to Table 67, the proportionate mortality from pulmonary tuberculosis in occupations with exposure to mineral dust is 27.3 per cent for all ages, which compares with 21.3 per cent as shown by the census occupation mortality returns. The differences are quite marked, and a maximum proportion is reached at ages 25 to 34, when out of 1,920 deaths from all causes among men with exposure to mineral dust, 875, or 45.6 per cent, are deaths from pulmonary tuberculosis, in contrast to a corresponding mortality of 49.6 per cent for men employed in occupations with exposure to metallic dust. The proportionate mortality from pulmonary tuberculosis among men employed in occupations with exposure to mineral dust must therefore be considered distinctly excessive, but particularly so at ages under 45. The mortality from nontuberculous respiratory diseases affects rather the more advanced ages, and this is especially the case with pneumonia, the incidence of which is apparently increased by exposure to the continuous and considerable inhalation of mineral dust, even more so than in the case of occupations with exposure to metallic dust.[1]

PROPORTIONATE MORTALITY BY INDUSTRIES OR OCCUPATIONS.

The proportionate mortality by specific industries or occupations and by divisional periods of life is shown in Table 69 following, which will facilitate comparison with the corresponding table for the registration area, but which is subject to the same suggestion of extreme caution as regards the interpretation of the data derived, as explained, from different sources.

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[1] The mortality from pneumonia in the registration area has apparently been decreasing during recent years, as shown by the following table, derived from official sources:

Mortality from pneumonia (exclusive of broncho pneumonia)—United States registration area, 1905–1915.

[Rate per 100,000 of population.]

	Males.	Females.	Total.
1905–1909	116.7	93.7	105.4
1910–1914	96.8	76.3	85.8
1915	91.5	73.8	82.9

No thoroughly qualified analysis has thus far been made of the mortality from pneumonia in the United States, particularly in its relation to the dusty trades. The subject is, however, deserving of more extended and strictly scientific consideration.

TABLE 69.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS IN SPECIFIED INDUSTRIES OR OCCUPATIONS WITH EXPOSURE TO MINERAL DUST, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, BY AGE PERIODS.

Occupation group.	15 to 24 years.			25 to 34 years.			35 to 44 years.			45 to 54 years.		
	Deaths from all causes.	Deaths from pulmonary tuberculosis.		Deaths from all causes.	Deaths from pulmonary tuberculosis.		Deaths from all causes.	Deaths from pulmonary tuberculosis.		Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent.		Number.	Per cent.		Number.	Per cent.		Number.	Per cent.
Asbestos workers	3	......	.....	3	1	33.3	3	2	66.7	1	......	.....
Brick, tile, and terra cotta	48	11	22.9	51	18	35.3	81	16	19.8	97	18	18.6
Core makers	113	36	31.9	98	42	42.9	63	19	30.2	42	5	11.9
Glassblowers	51	23	45.1	137	73	53.3	115	36	31.3	106	30	28.3
Glass cutters	53	21	39.6	55	28	50.9	48	20	41.7	28	6	21.4
Glassworkers, other	257	81	31.5	186	95	51.1	151	52	34.4	108	25	23.1
Lime, cement, and gypsum	18	2	11.1	40	15	37.5	48	12	25.0	45	10	22.2
Lithographers	70	37	52.9	81	42	51.9	69	27	39.1	53	13	24.5
Marble and stone workers	60	23	38.3	228	121	53.1	403	179	44.4	513	200	39.0
Molders	266	63	23.7	540	218	40.4	694	213	30.7	690	149	21.6
Paint factories	10	4	40.0	26	6	23.1	25	10	40.0	33	7	21.2
Paper hangers	57	20	35.1	175	77	44.0	174	74	42.5	134	21	15.7
Plasterers	58	20	34.5	163	71	43.6	225	91	40.4	281	66	23.5
Potteries	77	24	31.2	137	68	49.6	181	72	39.8	172	52	30.2
Total	1,141	365	32.0	1,920	875	45.6	2,280	823	36.1	2,303	602	26.1

Occupation group.	55 to 64 years.			65 years and over.			Age unknown.			Total, 15 years and over.		
Asbestos workers	1	......	.....	2	......	.....	....	......	.....	13	3	23.1
Brick, tile, and terra cotta	121	13	10.7	129	6	4.7	....	......	.....	527	82	15.6
Core makers	26	3	11.5	15	......	.....	....	......	.....	357	105	29.4
Glass blowers	52	8	15.4	85	5	5.9	....	......	.....	546	175	32.1
Glass cutters	24	2	8.3	11	3	27.3	1	......	.....	220	80	36.4
Glassworkers, other	103	16	15.5	92	5	5.4	....	......	.....	897	274	30.5
Lime, cement, and gypsum	49	6	12.2	22	1	4.5	....	......	.....	222	46	20.7
Lithographers	32	4	12.5	19	2	10.5	1	......	.....	325	125	38.3
Marble and stone workers	506	135	26.7	342	32	9.4	....	......	.....	2,052	690	33.6
Molders	624	87	13.9	480	28	5.8	....	......	.....	3,294	758	23.0
Paint factories	16	......	.....	14	......	.....	....	......	.....	124	27	21.8
Paper hangers	96	11	11.5	72	3	4.2	....	......	.....	708	206	29.1
Plasterers	330	39	11.8	314	13	4.1	....	......	.....	1,371	300	21.9
Potteries	147	31	21.1	87	11	12.6	....	......	.....	801	258	32.2
Total	2,127	355	16.7	1,684	109	6.5	2	......	.....	11,457	3,129	27.3

MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES.

On account of the importance of nontuberculous respiratory diseases,[1] Table 70 is included, showing the proportionate mortality from asthma, bronchitis, pneumonia, and other respiratory diseases among workers in occupations with exposure to mineral dust, without reference to divisional periods of life:

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[1] On the nontuberculous respiratory diseases, see "Diseases of the Bronchi, Lungs, and Pleura," by Frederick T. Lord M. D., Philadelphia and New York, 1915, and "System of Medicine," edited by Sir Clifford Allbutt and Humphrey Davy Rolleston, London, 1909.

TABLE 70.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES IN SPECIFIED INDUSTRIES OR OCCUPATIONS WITH EXPOSURE TO MINERAL DUST, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914.

Occupation group.	Deaths caused by nontuberculous respiratory diseases.									
	Asthma.		Bronchitis.		Pneumonia.		Other.		Total.	
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
Asbestos workers					2	15.3			2	15.3
Brick, tile, and terra cotta	6	1.1	5	0.9	68	12.9	10	1.9	89	16.9
Core makers			1	.3	40	11.2	7	2.0	48	13.4
Glass blowers	3	.5	6	1.1	32	5.9	8	1.5	49	9.0
Glass cutters	1	.5	1	.5	21	9.5	2	.9	25	11.4
Glass workers, other	4	.4	6	.7	71	7.9	13	1.4	94	10.5
Lime, cement, and gypsum	2	.9	3	1.4	15	6.8	5	2.3	25	11.3
Lithographers			3	.9	35	10.8	3	.9	41	12.7
Marble and stone workers	28	1.4	52	2.5	198	9.6	49	2.4	327	15.9
Molders	25	.8	51	1.5	463	14.1	65	2.0	604	18.3
Paint factories	1	.8			11	8.9			12	9.7
Paper hangers	1	.1	8	1.1	61	8.6	9	1.3	79	11.2
Plasterers	9	.7	23	1.7	135	9.8	9	.7	176	12.8
Potteries	25	3.1	14	1.7	46	5.7	19	2.4	104	13.0
Total	105	.9	173	1.5	1,198	10.5	199	1.7	1,675	14.6

It does not seem necessary, as observed in the discussion of occupations with exposure to metallic dust, to enlarge upon the facts disclosed by the preceding comparative statistics, which emphasize with a sufficient degree of scientific conclusiveness the obviously health-injurious consequences of considerable and continuous exposure to the inhalation of mineral dust. It is clearly recognized that the statistical data utilized for the present purpose are of rather limited intrinsic value, but they are in the main quite fully confirmed by the more extended consideration of occupations in detail where the exposure to mineral dust is sufficient to warrant their inclusion within the plan and scope of the present discussion.

ENGLISH OCCUPATIONAL MORTALITY DATA.

In conclusion, however, it has seemed advisable to add to the present observations a table obtained from English official sources which shows the combined mortality of glassworkers, potters, paper hangers, plasterers, and lithographers, and which may safely be considered sufficiently representative of the entire group of occupations with exposure to mineral dust, in the absence of more extensive information which unfortunately is not available.

TABLE 71.—MORTALITY FROM ALL CAUSES, FROM PULMONARY TUBERCULOSIS, AND FROM OTHER RESPIRATORY DISEASES IN OCCUPATIONS EXPOSED TO MINERAL DUST, COMPARED WITH THAT OF ALL OCCUPIED MALES, IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[Source: Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 due to all causes among—		Death rate per 1,000 due to pulmonary tuberculosis among—		Death rate per 1,000 due to other diseases of the respiratory system among—	
	All occupied males.	Occupations exposed to mineral dust.	All occupied males.	Occupations exposed to mineral dust.	All occupied males.	Occupations exposed to mineral dust.
15 to 19 years	2.44	2.35	0.54	0.55	0.24	0.27
20 to 24 years	4.41	4.02	1.55	1.44	.48	.50
25 to 34 years	6.01	5.24	2.03	2.01	.77	.78
35 to 44 years	10.22	12.46	2.74	3.96	1.66	2.12
45 to 54 years	17.73	23.74	3.04	4.91	3.32	6.05
55 to 64 years	31.01	40.23	2.16	3.94	6.54	12.86
65 years and over	88.39	92.60	1.11	1.13	17.77	24.50

GENERAL CONCLUSIONS.

Table 71 brings out clearly the fact that the mortality from pulmonary tuberculosis among men in occupations with exposure to mineral dust is decidedly excessive at ages 35 to 64, but that the mortality at the other ages is not appreciably lower than for occupied males generally. Death rates are, however, not as useful and conclusive for purposes of industrial hygiene as the proportionate mortality figure which precisely emphasizes the quantitative importance of a given disease or cause of death. The proportionate mortality from pulmonary tuberculosis and nontuberculous respiratory diseases is excessive at all ages among men with exposure to mineral dust, although the relative death rate per thousand exposed to risk is not, at least according to English experience, decidedly excessive at certain periods of life. The data are not of sufficient importance to invalidate the general conclusion, and in the main the death rates sustain the proportionate mortality figure, although this is not invariably the case. The death rate from nontuberculous respiratory diseases among men employed in occupations with exposure to mineral dust, according to the English experience, is at the older ages so decidedly excessive that obviously much more extended scientific consideration should be given to this group of diseases than has heretofore been given it. At ages 55 to 64, for illustration, in the English experience there is an actual excess in the mortality from all causes among men exposed to mineral dust of 9.22 per 1,000, equivalent to 29.7 per cent, but in the mortality from pulmonary tuberculosis there is an excess of 1.78 per 1,000, equivalent to 82.4 per cent, against an excess of 6.32 per 1,000 in the mortality from nontuberculous respiratory diseases, equivalent to 96.6 per cent. The results of this analysis, therefore, reemphasize the scientific conclusiveness of the extended discussion on "Industrial pneumoconiosis with special reference to dust phthisis," by Edgar L. Collis, in the Milroy Lectures of 1915, and the corresponding observations on pneumoconiosis by Sir Thomas Oliver in Allbutt & Rolleston's System of Medicine, Volume V, Diseases of the Respiratory System.

Of interest in this connection are the observations by Dr. J. S. Haldane contained in a contribution to the Proceedings of the Institution of Mining Engineers, abstracted in a letter from London to the Journal of the American Medical Association, August 19, 1916. In the paper referred to Dr. Haldane pointed out "that while up to the age of 50 the death rate from lung disease is much lower among colliers than in the rest of the population, above 50 the opposite holds, and there is a marked excess of deaths from bronchitis." In continuation, however, he stated that "the deaths from this disease have greatly diminished since 1890, for which improved ventilation seems to be the cause. Fifty years ago miners often worked in air containing so much black damp that lamps and candles burned dimly. In such air there is usually 2 or 3 per cent of carbon dioxide, which enormously increases the breathing during muscular exertion. The breathing is exactly regulated so as to keep an average of about 5.6 per cent carbon dioxide in the alveolar air; and with 3 per cent of this gas in the air, a man breathes twice as much air, so as to keep the alveolar percentage right. A man doing moderate muscular work in pure air breathes about five or six times as much air as during rest. In air containing 3 per cent of carbon dioxide he would be breathing ten or twelve times as much air as during rest, and his breathing would be taxed to the utmost. He would thus be much more liable to contract emphysema. The better ventilation of coal mines is largely a consequence of the greater amount of fire damp and great heat encountered as mines have become deeper."

Dr. Haldane is inclined to think "that both the fire damp and the heat have indirectly caused great improvement to the health of miners. Where there is plenty of fire damp there is usually also plenty of fresh and dry air, and no harmful excess of carbon dioxide. The proportion of deaths from bronchitis among old miners was higher in Staffordshire in 1890–1892 and 1900–1902 than in any of the other coal fields; and Staffordshire mines are exceptionally subject to black damp. The excess in bronchitis among old coal miners has been attributed to the breathing of dust," and Dr. Haldane was "previously inclined to agree with this theory. But it is difficult to see why, if dust is the cause, there has been so great a diminution in the bronchitis mortality in recent years. Coal mines have, on the whole, become drier and more dusty with increasing depth and better ventilation; and, if dust were the cause, one would have expected the bronchitis to increase, whereas it has greatly diminished. Certainly an excess in mortality from bronchitis is associated with the breathing of harmful dust. But this excess is accompanied by a far greater excess in mortality from phthisis, and begins comparatively early in life, unlike the bronchitis mortality in colliers. Experiments on animals carried out by J. M. Beattie show that both coal dust and the shale dust usually associated with it on mine roads are relatively harmless."

It is therefore quite clear that much remains to be ascertained concerning the true nature and extent of dust phthisis and that in the solution of this important industrial problem a considerable advance is necessary in the practice of medicine, which to a much larger degree should be made to rest upon knowledge concerning disease causation ascertained by means of autopsies in industrial districts subject to an excessive mortality from pulmonary tuberculosis and nontuberculous respiratory diseases.

ASBESTOS.

The number of men employed in trades and industries involving exposure to asbestos dust in the United States is unknown. Aside from the mining of asbestos, in which exposure is rather limited, there are numerous processes involving the conversion or remanufacture of the materials which are distinctly more serious in their effects on health and longevity. Asbestos weaving and spinning are described by Netolitzki on the basis of observations in Bohemia, where the conditions were found to be decidedly unfavorable. For this country our information is very limited, although the quantity of asbestos used is very large. Its fire-resisting properties have led to its extensive employment for the covering of pipes, furnaces, etc., as well as its use in the form of wall plaster, roofing material, etc. On account of its nonconducting qualities it is extensively employed by electricians and also in the construction of storage rooms of refrigerating plants.

METHODS OF MINING.

"Geologically," according to the Technical World Magazine,[1] "asbestos is a fibrous form of serpentine rock, occurring in strata of crystalline limestone. The veins run in an average thickness of one-fourth to one-half inch, but sometimes attain to as much as 6 inches.

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[1] "Mining mineral wool," by Aubrey Fullerton, in Technical World Magazine, May, 1906.

The asbestos fibers are, as nearly as possible, crystals of serpentine rock." According to the same magazine—

> The ore is mined mostly in open quarries. Overlying soil, to a thickness of sometimes 20 or 30 feet, but quite often forming only a thin layer on top, has first to be removed; and as soon as the asbestos veins are thus laid bare, the actual quarrying operations may begin. The rock is cut in a series of terraces, reaching a total depth of sometimes 150 or 200 feet. Underground work has not proved successful, the open quarry having been found both more economical and more effective, despite the disadvantages of exposure to the weather. Drilling and blasting are employed much the same as in ordinary stone quarrying.
>
> When the rock is thus broken up it is rough sorted at the quarry. Two or more grades are selected, according to the length of the fiber, and are then sent on to the "cobbing sheds," where the further process of dressing goes on. This process is merely the separation of the asbestos fibers from the dead rock, and is done in some cases by hand, but to an increasing extent by machine. Hand cobbing is the very simple method of breaking the stone by small sledge hammers, throwing the fiber into one box and the waste into another. This separation is ordinarily not difficult, since the fiber lies in layers more or less loosely clinging to the rock, and can frequently be picked off with the fingers. The crude fiber, thus separated as cleanly as possible from the waste rock and looking very much like mineralized wool, is packed in 100-pound bags, in which form it goes to the market and the manufacturer.
>
> Hand dressing is not, however, an absolutely thorough method. The waste material from the cobbing tables and the fine pickings from the quarries have still some fiber in them, and the utilization of this frequently represents the largest profits of the mine. All these fine pickings are mechanically dressed. In case the asbestos contains a large percentage of water, the moisture is first dried out, by exposure to the air, by steam pipes, or by rotary driers, and the rock is then passed on to the crushers, where it is broken by successively finer-set rolls. Cylindrical fiberizers and the cyclone machine reduce it still further. The latter is the most effective apparatus yet devised for asbestos separation. It consists of two beaters, one of the screw-propeller type, driven within a cast-iron chamber at a violent speed, reducing the particles of stone almost to a powder. This is then passed over a shaking screen to remove the sand, and in some mills strong electric magnets are used to take up the particles of iron.

In all of these operations there must necessarily be a considerable degree of dust exposure, which, however, becomes exaggerated in the spinning and weaving processes in connection with the manufacture of asbestos yarn and cloth. These processes are briefly referred to in an article in the Engineering Magazine,[1] in part, as follows:

> The spinning and weaving of asbestos have offered many difficulties, as the asbestos fibers have no rough surface like wool or cotton, but

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[1] "Asbestos, its mining, preparation, markets, and use," by E. Schaaf-Regelman, Engineering Magazine, Oct. 1907.

are very smooth, and thus have a tendency to slip by one another when twisted and subject to tension. An admixture of vegetable or animal fiber was therefore often necessary, but, while these facilitated the manufacturing operations, they impaired the fire resistance of the fabric, and special machinery and ingenious devices had to be invented to enable the successful spinning of a pure asbestos yarn. It is, however, now possible to make a single asbestos thread which, though weighing no more than 1 ounce per hundred yards, has a fair strength, and braided material can be made much more resistant to torsion and tension, while asbestos ropes, chiefly used by the fire department, can be strengthened either by interwoven wires or by having a wire-rope core.

HEALTH-INJURIOUS OCCUPATIONAL CONDITIONS.

On account of the rather limited extent of the asbestos industry in the United States, at least in the large centers of population, the industrial insurance mortality experience data are insufficient for definite conclusions. During the period 1907 to 1914 in the Prudential experience there were only 13 deaths, of which 3, or 23.1 per cent, were from pulmonary tuberculosis. At ages 25 to 44, there were 6 deaths, of which 3, or 50 per cent, were from this disease. Asbestos dust is not described in the extensive consideration of Dust Hazards, by Hayhurst, nor by W. Gilman Thompson in his treatise on The Occupational Diseases. In 1914 the production of asbestos in the United States was only 1,247 tons, or much less than in earlier years, indicating a very limited available source of supply. Most of the asbestos used in the United States is mined in Canada, and an excellent report on " Asbestos, its occurrence, exploitation, and use," has been published by the mines branch of the Department of the Interior of the Dominion of Canada (Ottawa, 1905), which contains a descriptive account of mining methods and of the dressing of asbestos by hand or by mechanical treatment, including the final crushing by means of rollers, fiberizers, beaters, cyclones, and pulverizers. All of these processes unquestionably involve a considerable dust hazard, but the hygienic aspects of the industry have not been reported upon. It may be said, in conclusion, that in the practice of American and Canadian life insurance companies asbestos workers are generally declined on account of the assumed health-injurious conditions of the industry.[1]

It is regrettable that there should be no further information available regarding the asbestos industry in its various branches, including the utilization of by-products of manufacture, on account of the self-evident injuriousness of asbestos dust as a predisposing cause of pulmonary tuberculosis. The subject is not referred to by Kober and Hanson in their recently published treatise on Diseases of Occupation and Vocational Hygiene, nor by Sir Thomas Oliver in his recent work on Diseases of Occupation. The rapidly increasing development of industries using asbestos, as ascertained from domestic or foreign sources, suggests the urgency of more qualified medical consideration than has heretofore been given the subject. There are no references to asbestos in the Index Catalogue of the Surgeon General's Library, which, however, brings the literature of the subject down only to 1896. The discussion of asbestos in the annual reports of the United States Geological Survey on Mineral Resources is limited entirely to the technical aspects of the mining industry, which during recent years has experienced a rather retrograde movement in that the production has diminished from a maximum of 7,600 tons in 1911 to 1,247 tons in 1914. In contrast, however, there has been a gradual increase in the quantity of the unmanufactured asbestos imported, chiefly from Canada. The American production is practically limited to the States of Arizona, California, Georgia, and Vermont. Georgia has for years been one of the chief producers of asbestos in the United States, but no medical observations are on record as regards the possibly injurious results experienced in the mining and manufacturing of asbestos materials in that State. The industry itself has been described, however, in a report on the asbestos, talc, and soapstone deposits of Georgia in Bulletin No. 29 of the Georgia Geological Survey, 1914.

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[1] For a descriptive account of the Canadian asbestos district, see Engineering and Mining Journal, New York, Apr. 30, 1910.

EVIDENCE OF DUST EXPOSURE.

The relation of asbestos dust to pulmonary tuberculosis is reported upon at some length in the Annual Report of the Chief Inspector of Factories and Workshops for England and Wales for 1910. The investigation was made by Dr. Collis, who states, in part, that—

> Following up information received from the registrar-general, it was found that five deaths of persons suffering from phthisis had occurred in five years among a staff of under 40 workers employed at a factory where asbestos is woven.. The process which appeared most dangerous is the production of asbestos mattresses. These mattresses, which are composed of bags of woven asbestos filled with short asbestos fiber, are placed on a table and beaten out flat by a man with a wooden flail, from which process much dust arises. Women who sew the mattresses into sections with asbestos threads worked close to the man who beat the mattresses and of necessity inhaled the dust. The reorganization of this process with the application of localized exhaust draft was called for, and an annual medical examination of the workers by the certifying surgeon has been instituted in the hope of detecting and removing from exposure to dust those showing early signs of respiratory disease. Weaving asbestos has only become an important industry during the last 15 years. Two other large asbestos factories were visited, each of which was found to have its own specialty in the production of which dust prevention is required.

There is evidently an urgent need for a more qualified and extensive investigation of the health aspects of asbestos manufacture; especially so, in view of the fact, as observed in the Scientific American (August 1, 1916), that, on account of the restrictions placed upon shipments of asbestos from Canada, the possibilities of utilizing the asbestos deposits of this country are increased, as well as because of the much larger demand for asbestos products on account of the recognized value of asbestos for protective purposes in the furtherance of the industrial safety movement. Of value in this connection is the evidence of Dr. H. M. Murray before the Departmental Committee on Industrial Diseases, limited, however, to the single case of an asbestos worker, verified as regards diagnosis by a post mortem examination. In reply to a question by the chairman of the committee as to whether, in view of the fact "that there is something characteristic in the earlier stages of dust phthisis in the predominance of shortness of breath before physical signs become very obvious," such a condition had been observed in the case of the asbestos worker under treatment by Dr. Murray, and under observation for fourteen months, the doctor said that it had been noticed in the case in question, and that, in other words, there was a definite relation between the course of phthisis and the physical incapacity resulting from the inhalation of asbestos dust. It is therefore to be anticipated that the condition of asbestos workers will attract more qualified attention in this country in the future than it has in the past.

MICA.

No special investigation has been made to ascertain the more or less health-injurious effects of mica dust. According to W. Gilman Thompson the dust is slightly irritating to the respiratory system, like dust containing any sharp solid particles, but as a general conclusion he states that the dust does not appear to be particularly injurious. Mica is extensively used in the manufacture of electrical machinery, as well as in the glazing trade, as a substitute for glass, and in the decorative trades, including the manufacture of wall paper. There are two principal varieties of mica, known as muscovite and phlogopite, but whether there is any essential difference between the physical and mechanical properties of the dust has not been determined. There are mica deposits in some 20 States of the United States, but the annual production has fluctuated considerably, reaching the lowest point in the last decade during 1914. Whether there are any special hazards in mica mining in consequence of the dust has not been ascertained. The occurrence, exploitation, and use of mica have been admirably described in a report published by the mines branch of the Department of the Interior of Canada. The report, however, includes no observations on the sanitary aspects of the various employments. It is pointed out, with special reference to the manufacture of ground mica, that the difficulties of grinding are great, owing to the tough and scaly nature of the mineral, which may be assumed to indicate that even when reduced to a fine powder the dust is apparently not of very serious importance to the employees.

Mica dust is briefly referred to by Kober and Hanson in their Diseases of Occupation and Vocational Hygiene, in which it is said that mica is "a mineral of widely varying chemical composition, but is essentially composed of silicates of aluminum and an alkali, such as potassium, sodium, or lithium." It is stated that the mineral splits easily into thin, flexible, colorless, transparent plates or scales, known as isinglass, and that in the powdered form it is employed in the manufacture of giant powder, and that it is also used for decorative purposes, chiefly in the manufacture of wall paper, illuminated designs, etc. The only medical conclusion arrived at by the authors is that "mica dust is doubtless a frequent cause of inflammatory conditions of the eyes and air passages." It is therefore suggested by inference that the dust in finely comminuted form may also have an irritating effect upon lung tissue, and to that extent predispose mica workers to pulmonary tuberculosis, although much more extended observations are required before definite conclusions can be arrived at.[1]

THE STONE INDUSTRY.

The stone industry in the United States is of vast areal extent and commercial importance. The product for 1914 was valued at nearly $80,000,000. Stone is quarried or produced in every State and Territory, and the number of persons employed in the stone industry exceeds 100,000. The principal varieties are granite, trap rock, marble, limestone, and sandstone. The industry may broadly be divided into the manufacture of crushed stone for road making and other purposes, paving stone, building stone, and monumental stone. The two latter are subdivided into rough and dressed products. The labor conditions in an industry of such vast extent and fundamental differences in the nature of the product must necessarily vary widely, but from a hygienic point of view the essential difference arises out of the mechanical and chemical properties of the dust produced in the quarrying, the dressing, and the polishing of the different varieties, which are too numerous to permit of even a brief technical description.

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[1] For a valuable descriptive account of mica, see the National Museum Report, 1899, p. 283.

For a discussion of mica mining in the United States with special reference to underground conditions, see an article in the Engineering and Mining Journal, May 8, 1909. With reference to mining methods in Canada, see an article in the same publication in the issue of April 18, 1908.

See also an extended discussion by Mr. C. Hanford Henderson on "Mica and the mica mines," in the Popular Science Monthly for Sept., 1892.

According to a statement by the manager of the Crown Mica Co., of Custer City, S. D., "Mica mining is considered very healthy, as most of it is done in open cuts."

EARLY OBSERVATIONS ON HEALTH-INJURIOUS CONDITIONS.

The health of stone and marble cutters has, from earliest times, been held to be notoriously bad, and the hygienic importance of this trade was recognized by Ramazzini, who, as far back as 1705, discussed the subject in an entire chapter in his work on Diseases of Tradesmen, stating that—

> In hewing marble or stones out of the rock, in polishing and cutting them, they oftentimes suck in, by inspiration, the sharp, rough, and cornered small splinters or particles that fly off; so that they are usually troubled with a cough, and some of them turn asthmatic and consumptive. * * * Our medical histories give many instances of stones found in the stomach and lungs of these workmen, for which we can assign no other material cause but the dusty particles taken in at the mouth and gradually gathered into a heap. * * * Withal, all possible caution must be used to avoid the sucking in of these minute particles at the mouth.

From the earliest to the most recent observers upon the health conditions in this trade, the conclusions have been decidedly unfavorable and suggestive of circumstances more or less possible of material improvement. Oliver, in his Diseases of Occupation, remarks, with special reference to stonemasons:

> The occupation of the stonemason and of the quarryman has for long been regarded as one in which a higher death rate from lung disease occurs than in most occupations. The disease, which usually assumes a chronic character, is slow in its development and progress. As it is attended by the ordinary physical signs and symptoms observed in other forms of pneumoconiosis, the malady calls for no special description other than this, that in contradistinction to miners' phthisis, which occurs in men who work underground, stonemasons' phthisis is met with in men who are working in the open air, a circumstance which becomes a strong argument in favor of the dust origin of pneumoconiosis as against the bacillary. After a time the lung disease becomes tuberculous, hence the extraordinary fact of the death rate from pulmonary tuberculosis among stonemasons and marble cutters, who are following an outdoor occupation, being six times that of bankers and brokers, who are leading an indoor life. This want of harmony between occupation and mortality from pulmonary phthisis is observed in other outdoor occupations than stonecutting. It would appear, therefore, as if the predisposing causes of lung disease are often of greater importance than the exciting—in other words, that the soil is of as much, if not of greater, influence than the seed. The irritation of the lung caused by dust would seem in some instances, especially in the early stages of the disease, to

create a favorable soil for the implantation of the tubercle bacillus, while in the slowly developed forms of pneumoconiosis the hard and unyielding fibrous tissue does not offer the same attractions to the microorganism, and as a consequence it is in those parts of the lung where the structure is least fibrous that the tubercle bacilli exert their greatest power for harm.[1]

EXPERIENCE OF THE OPERATIVE MASONS' SOCIETY OF LONDON.

The remarks of Oliver are fully sustained by the available statistical evidence. The secretary of the Operative Masons' Society of London, in his testimony before the committee on industrial diseases, produced the mortality record for Newcastle for the period of 1871 to 1896, including an account of 160 deaths of stonemasons, and of this number 71, or 44.4 per cent, had died from phthisis, at an average age of only 42.23 years. It was admitted, however, that conditions had improved, and more recent data resulted in a more favorable showing. Out of 253 deaths of stonemasons reported in 1905 by the same society, 79, or 31.2 per cent, were deaths from pulmonary tuberculosis. The same witness stated that the average age at death of those dying from phthisis during 1905 was 44 years, against 51 years for deaths from all causes.[2]

DESCRIPTIVE ACCOUNT OF OCCUPATIONAL CONDITIONS.

Conditions are probably somewhat different in this country, due to the more general use of pneumatic tools, which generate considerable quantities of fine dust, the complete prevention of which is always difficult and often impossible. The degree of disease liability varies materially according to the specific occupation, and the risk is less in the case of paving-stone cutters and slate splitters than in the case of monument or custom work, which requires close attention in matters of minute detail and which is more often carried on indoors. Surfacing and carving and cutting with pneumatic tools are the most dangerous employments, the risk being less in polishing, grinding, sawing, and lathe work, most of which is carried on by the wet process. Large quantities of dust are stirred up, however, in the brushing off and cleaning up of the accumulated dust, and in the moving of materials, dropping of slabs, etc. There is, therefore, more or less dust exposure in all branches of the stone industry, but the results of exposure vary according to the kind of material, which includes a large variety of stones, chiefly, however, granite, marble, limestone, sandstone, bluestone, and slate.

The stonecutters' trade is one which requires both skill and arduous physical labor. The men as a rule work in the open air, and in very warm or wet weather under shelter; but all are liable to inhale the dust and small particles from the material upon which they operate. This on some kinds of stone is much more deleterious to health than on others, the stone containing the largest proportion of flints being much more injurious than that which has most lime in it. The returns show that the present age of stonecutters is three years less than that of carpenters or masons, while the average number of years at work exceeds that of either by nearly one year. But this is accounted for by reason of the difference in the ages at which they began to work, which for 63.9 per cent of stonecutters was under 15 years of age, while in the other two trades mentioned it was 13.8 per cent and 4 per cent, respectively. The explanation is that in England, Ireland, and Scotland, as well as in other European countries, seven years are the rule for apprenticeship of stonecutters, and a large proportion are taken when 12 years old, and quite a number under this age. Eighty-three and one-half per cent of the total number were foreign born and but 16.5 per cent American born; and of the latter but nine-tenths of 1 per cent began to work under 15 years of age; while 15.4 per cent of carpenters and 25.6 per cent of masons began to work at their respective trades after the age of 20 years and upward, none of the stonecutters had reached this age. This fully accounts for the differences above noted.[1]

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[1] Diseases of Occupation, London, 1908, p. 305.

[2] Minutes of Evidence, Departmental Committee on Compensation for Industrial Diseases, p. 322.

In his discussion of the hygiene of this occupation Lloyd[2] makes the following observations:

> Stonecutters and quarrymen suffer in various degrees from the inhalation of dust. The extent of the evil in their cases depends upon, first, the character of the dust, and, second, the circumstances amid which the work is pursued. The quality of the stone has much to do with the extent of pulmonary disease among stonecutters. Some stone is much more dusty than others. A sedimentary stone, for instance, that was formed originally simply by the deposit of earthy and siliceous particles under water is much more liable to give off a large quantity of dust than is a stone that was fused in early geological ages—the igneous stones, for instance, like granite. Although the particles from these latter stones are exceedingly hard, yet there is not much true dust, only the particles actually displaced by the contact with the tool being thrown off. These probably do not carry far in the air, and are mostly too large to gain access to the alveoli as dust. This was the explanation given by Hamilton, of Aberdeen (quoted by Arlidge), for the fact that the masons and polishers at the Aberdeen quarries do not suffer much, if any, with industrial phthisis.

RESULTS OF OFFICIAL INVESTIGATION IN MASSACHUSETTS.

A brief abstract from a special report of the Massachusetts State Board of Health on dangerous occupations,[3] as suggestive evidence particularly applicable to American conditions at the present time, is included here:

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[1] Fourteenth Annual Report of the Bureau of Statistics of Labor and Industries of New Jersey, 1891, pp. 176, 177.

[2] "The diseases of occupations," by James Hendrie Lloyd, M. D., published in Twentieth Century Practice of Modern Medical Science, New York, 1895, Vol. III, p. 420.

[3] Commonwealth of Massachusetts, Senate Document No. 250, Boston, March, 1907, pp. 78, 79.

It is preeminently a dusty trade, and the workmen are therefore exposed to the danger of inhaling nonabsorbable and irritating particles of mineral matter. Accidents to the eyes from flying chips are also very common, but they are generally less serious than those due to fragments of steel from the tools employed. Of the various kinds of stone dust, granite is regarded as more injurious than marble, and soapstone the least of all; but different granites vary in this particular, some yielding a much finer dust than others, on account of differences in texture. The greatest amount of dust comes from the surfacing machines, which are operated with compressed air. The tool is either a large hammer or an instrument which presents four smaller separate faces. Sometimes a bushing hammer, made of thin, chisel-like blades bolted together, is used; this creates the finest dust of all. The men who operate the surfacing tools rarely wear masks, but many chew tobacco and spit, in the belief that the practice serves to protect them from the effects of the dust to which they are exposed. Some protect themselves from flying chips by means of wire screens placed about the hammer; some wear wire masks and some wear glasses. By a union regulation, surfacing is done in the open sheds in the yard. While the operation of smoothing can not be done by the wet process, on account of clogging of the tools with the pasty material which would thereby be produced, polishing is conducted with the application of water, which prevents the evolution of dust. The sawing of granite and marble into slabs is conducted ordinarily by the wet process, and is therefore unattended by dust; but soapstone sawing and cutting for joints is frequently done dry, and with the evolution of much fine dust. Turning in lathes is conducted in the wet way, and is dustless.

Of 343 deaths which occurred in the city of Quincy among stonecutters during a period of about 16 years, no fewer than 142 (41.4 per cent) were due to pulmonary tuberculosis, 41 (12 per cent) to other diseases of the lungs, 44 (12.8 per cent) to diseases of the heart, 24 (7 per cent) to violence, and 92 (26.8 per cent) to all other causes. Excluding accidents, the percentage due to tuberculosis was 44.5. These statistics show even more strikingly than those quoted in a report submitted two years ago the dangerous character of this occupation. Therein it appears that, of a total of 30,000 deaths among stonecutters, tuberculosis was the cause in 28.57 per cent. It must be said, however, that the average age at death of the victims of the disease in this industry, so far at least as the Quincy records show, is somewhat high (47.8 years), but it is to be borne in mind that the calling is one which is not open to the naturally weak, and that many of those who become incapacitated through infection drift into other lines of industry in which physical strength is not so essential, and hence at death are not returned as belonging to this class.

URGENCY OF SPECIAL SCIENTIFIC INQUIRIES.

No very satisfactory data for this country are available to determine with accuracy the probable degree of difference in the health-injurious conditions resulting from the cutting or manipulation otherwise of the different kinds of stone, such as granite, sandstone, limestone, bluestone, slate, etc., except marble cutting, to be separately considered as a well-defined branch of the trade. The term "stonecutters" is, therefore, practically inclusive of workers in all branches of the industry and in all the different employments necessary in connection therewith. An observer of conditions in the sandstone industry states that "stonecutters who work on sandstone seldom live to be 50 years of age, and nearly all of them die of lung disease, due to the inhalation of mineral dust"; but how far this is sustained by actual experience in the regions where sandstone is quarried and cut can not be stated at present. A physician of long residence in the Bedford, Ind., limestone field, states that he has not observed very serious consequences to result from employment in that branch of the stone industry, but all such observations are subject to serious error in the absence of trustworthy statistical data for a period of years.

DIFFERENTIAL EFFECTS OF DUST EXPOSURE.

These differences of qualified opinion regarding the relation of stone dust to health arise obviously out of the wide variations in the physical, mechanical, and chemical properties of the different kinds of stone subjected to modern processes of quarrying, dressing, etc., particularly in consequence of the extensive use of modern pneumatic tools used for stonecutting purposes. Among all branches of the dusty trades and occupations the stone industry is of the first order of scientific importance. Aside from the industry itself, as regards the production of stone for commercial purposes, practically the entire mining industry is in a measure a branch of the stone industry, in that all the metals and nonmetallic minerals obtained by mining methods are obtained by processes of extraction from rock material more or less identical with the substances which enter into the stones quarried and cut for commercial purposes. The most thorough and strictly scientific study of dust phthisis with special reference to the stone industries has been made by Dr. Edgar L. Collis, His Majesty's medical inspector of factories, presented in the Milroy Lectures of 1915. The differential effects of dust containing a large proportion of free silica (quartz) and dust relatively free therefrom are emphasized in the most concise and conclusive manner.

LUNG DISEASES OF FLINT KNAPPERS AND BUHRSTONE DRESSERS.

The correlation of these conditions to the relative frequency of true phthisis or of lung fibrosis, with a subsequent tuberculous infection, is made clear on the basis of indisputable clinical evidence amplified by numerous Roentgen ray examinations. Stone dust containing but a relatively small proportion of free silica, such as limestone, is considered comparatively harmless, while the extreme seriousness of stone dust consisting chiefly of free silica (quartz) is illustrated by numerous concrete cases, of which the so-called flint knappers and French buhrstone dressers are the most striking and lamentable examples. Dr. Collis defines the term "pneumoconiosis" as one which should be restricted to "disturbances in health following upon changes induced in the lungs by inhalation of nonviable particles." And he remarks that "just as all germs are not pathogenic, so all kinds of nonviable particles do not give rise to pneumoconiosis." This extremely important conclusion in its particular application to the stone industry requires constant application to the more specialized consideration of its injurious results in employment in the different branches of the industry. Referring to the flint knappers of Brandon as the lineal occupational representatives of the oldest of all industries, that of the making of prehistoric stone tools and weapons, he states that they "suffer a terrible mortality from phthisis induced by flint dust generated in their work," and he recalls the results of earlier observations as regards the lamentable consequences produced among the population of Meusnes, France, by the introduction of the gun-flint industry, which, according to Chateauneuf, "slays those who follow it; it kills them before their time; for them there is no old age." He illustrates these observations by a most interesting analysis of the mortality from phthisis among flint knappers in the Brandon district, shown in Table 72.

TABLE 72.—MORTALITY FROM PHTHISIS OF FLINT KNAPPERS COMPARED WITH THAT OF CERTAIN OTHER CLASSES.

Class.	Cause of death, stated as percentages from—				Total number of deaths.	Average age at death.	Calculated death rate from phthisis per annum among 1,000 living.
	All causes.	Phthisis.	Respiratory diseases other than phthisis.	All other causes.			
Flint knappers [1]	100.0	77.8	7.4	14.8	27	46	41.0
Wives (2) and widows (11) of flint knappers.	100.0	....	15.4	84.6	13	78	....
Brandon rural district [2]	100.0	6.5	11.7	81.8	63	....	.8
All males (England and Wales, 1900-1902) [3]	100.0	11.2	17.6	71.2	509,567	(4)	1.6

[1] Average number employed for 25 years estimated at 16.5.

[2] Population about 5,150. The figures for this class, supplied by Dr. A. Harris, M. O. H., Thetford, Norfolk, are for all ages, 1901-1910.

[3] The figures for this class, calculated from the Supplement to the Sixty-fifth Annual Report of the Registrar-General, are for all males aged 15 years and upward, 1900-1902.

[4] Median age at death between 56 and 57.

MIXED MINERAL AND METALLIC DUST EXPOSURE.

Next to the inhalation of steel dust the continuous and considerable inhalation of flint dust is one of the most serious industrial conditions predisposing to pulmonary tuberculosis. In the pottery industry (see pages 247 to 271), the employees who handle or employ flint dust in connection with production processes are known to be subject to an exceptionally high mortality from pulmonary tuberculosis; so much so that flint workers generally are considered uninsurable by all American life insurance companies.

SECONDARY IMPORTANCE OF BACILLARY INFECTION.

The effects of stone dust in the mining industry are briefly set forth in the conclusions of the departmental committee appointed in 1902 to reinvestigate the causes of the persistently high phthisis mortality among Cornish tin miners, which, excluding all other contributory circumstances, except dust inhalation, decided that—

> So far as the Cornish miners are concerned it seems evident enough that stone dust which they inhale produces permanent injury of the lungs—gradually in the case of ordinary miners and rapidly in the case of machine-drill men—and that this injury, while it is apparently capable of gradually producing by itself great impairment of the respiratory functions, and indirectly of the general health, also predisposes enormously to tuberculosis of the lungs, so that a large proportion of miners die from tubercular phthisis. That the primary injury to the lungs is due solely to inhalation of stone dust would seem to be practically certain.

In other words, the more generally recognized menace of bacillary infection in tuberculosis was considered of secondary importance as a causative factor in the production of so-called miners' phthisis, more directly and specifically attributable to the continuous and considerable inhalation of silica dust. A descriptive account of the different varieties of dust, based on the microscopical examination of their physical and mechanical properties, is, therefore, a prerequisite for a thorough understanding of the pathological consequences of dust inhalation in the different branches of the stone industry. It is pointed out by Collis that all classifications in general use are inadequate to the purpose and that in the main it seems best to ascertain, first, the relation of each of the main respiratory diseases to dusts, and then from that standpoint to examine the properties of the dusts which are associated with an undue prevalence of each of these diseases. This, of course, implies a much broader plan and scope than the present investigation, which for practical purposes is limited chiefly to pulmonary tuberculosis. The chemical properties of dusts are occasionally of major importance on account of the solubility of certain kinds of dust, best illustrated in the case of the cement industry. As observed by Collis—

> Only particles which are insoluble in the fluids of the body when carried into the air passages remain as foreign bodies either to

stimulate the ciliated epithelium to overaction for their expulsion, or, if they gain access to the lymph channels, to give rise to a proliferation of the connective tissue; thus dusts of ivory, horn, bone, and other animal structures, and of calcium sulphate (plaster of Paris and alabaster), of limestone, and of oxide of iron are not associated with pneumoconiosis in the way that dusts of vegetable husks, emery, glass, sandstone, and flint are.

He adds to this extremely important practical conclusion the observation that, "generally speaking, dusts are more injurious as their chemical composition differs from that of the human body, or from the elements of which the body is normally composed."

MORBIDITY AND MORTALITY OF THE STONE WORKERS OF DERBYSHIRE.

The most useful application of the theory and conclusions of Dr. Collis is to be found in the extended study which has been made of the different branches of the stone industry of Derbyshire by Dr. Sidney Barwise, in a report to the county council of Derbyshire, on the basis of a careful study of the relation of phthisis incidence to the surface geological formation. Dr. Barwise ascertained that there was an excessive frequency of pulmonary tuberculosis on areas showing millstone grit, and a preliminary investigation indicated that "the key to the higher phthisis mortality in the gritstone area was to be found in the occupations of the males." A subsequent analysis of the mortality record for a period of 10 years proved conclusively that the gritstone quarries experienced an exceptional mortality from phthisis. It was found that of the deaths of quarrymen 29 per cent was from phthisis, while only 4.6 per cent of the deaths of agriculturists was attributed to this cause. On the basis of the calculated death rate, without reference, however, to the age distribution of the employees, it was shown that the death rate from phthisis among the agricultural group of the county was 0.72 per 1,000, while among the quarrymen and masons (stonecutters, dressers, etc.) it was 5, or seven times as great. Subjecting the data to a thoroughly specialized and qualified analysis, it was then ascertained that "among the limestone workers there was not an excessive mortality from phthisis, so that the mortality of gritstone workers separately considered was even higher than indicated by the combined mortality rate for all quarrymen and stone workers in the section under consideration. The results of this exceptionally valuable, and, broadly speaking, scientific investigation, are set forth in Table 73, derived from the "Report on the Prevalence of Phthisis among Quarry Workers and Miners," made by Dr. Sidney Barwise to the Derbyshire county council, February 6, 1913.

TABLE 73.—DEATHS FROM PHTHISIS OF MALES OVER 15, AND NUMBER OF MALES OVER 10 ENGAGED IN CERTAIN OCCUPATIONS, WITH DEATH RATES FROM PHTHISIS PER 1,000 MALES OVER 10 ENGAGED IN SUCH OCCUPATIONS, 1901 TO 1910.

District.	Stone-workers' group.			Agriculture.		
	Workers.	Phthisis deaths.	Rate per 1,000.	Workers.	Phthisis deaths.	Rate per 1,000.
Matlock registration subdistrict (chiefly gritstone):						
The two Matlocks and the two Darleys	426	31	7.3	473	2	0.4
Certain rural parishes	233	15	6.4	245	3	1.2
Total, Matlock registration subdistrict	659	46	7.0	718	5	.7
Bakewell registration subdistrict (gritstone and limestone):						
Bakewell, Baslow, and certain rural parishes in Bakewell registration subdistrict	530	20	3.8	1,079	10	.9
Tideswell registration subdistrict (chiefly limestone):						
Certain rural parishes in Tideswell registration subdistrict	339	10	2.9	579	2	.31
Total, Bakewell registration district	1,528	76	5.0	2,376	17	.72

COMPARATIVE PHTHISIS DEATH RATES ACCORDING TO DUST EXPOSURE.

According to this table the gritstone workers, who predominate in the Matlock subdistrict, show a phthisis rate of 7 per 1,000, or ten times greater than the agricultural group, whereas in the Bakewell subdistrict, where both limestone and gritstone deposits are worked, the rate is only 3.8, and in the Tideswell subdistrict, in which the proportion of gritstone workers is still less, the rate is only 2.9. Subjecting the returns for the Matlock and the Tideswell subdistricts to further analysis, it is shown that the phthisis mortality during the period 1901–1910, limited strictly to the workers themselves, is 13.7 per 1,000 for gritstone workers (chiefly exposed to insoluble pure silica dust); whereas in the case of limestone workers, chiefly exposed to a dust more or less soluble, the rate is only 1.2. In other words, the phthisis mortality of gritstone workers is more than ten times the corresponding mortality of limestone workers. It should be said in this connection that the number of men exposed to risk was 124 in the case of gritstone workers, with 17 deaths from phthisis, and 170 in the case of limestone workers, with 2 deaths from phthisis during the 10-year period. The results of the investigation are summarized in a convenient form in Table 74.

TABLE 74.—COMPARATIVE PHTHISIS DEATH RATE IN DERBYSHIRE COUNTY, ENGLAND, 1901 TO 1910.

	Persons.	Rate per 1,000.
Gritstone workers	124	13.7
The two Matlocks and the two Darleys, stoneworkers (some in limestone)	426	7.0
Bakewell registration district, gritstone and limestone works	1,528	5.0
Persons employed in and about limestone quarries and works	1,282	1.71
Limestone workers	262	1.52
Persons employed in and about coal mines	1,757	.68
Persons employed in agriculture	3,615	.66
Standard phthisis death rate	15,152	.77

In addition it was found that among those employed in gritstone working, the proportionate mortality from phthisis was 45 per cent, and among quarrymen and miners in the same district and working on the same material 36.6 per cent, in contrast to a proportionate mortality of 12.3 per cent for men employed as quarrymen and miners in the limestone area, and 7.4 per cent among the men employed in coal mining. The highest proportionate mortality among agricultural workers in the same district in which the proportionate mortality of gritstone workers was 45 per cent was only 7.9 per cent. The extremely injurious nature of gritstone dust, which is largely pure silica in a crystalline form, with special reference to pulmonary tuberculosis, is, therefore, conclusively established by these investigations.

AMERICAN MORTALITY STATISTICS.

The Vermont State board of health has reported the mortality by occupations during the six years ending with 1905, and during that time there were 204 deaths from all causes among the granite and other stone workers in that State. Of these deaths, 80, or 39.2 per cent, were from pulmonary tuberculosis, and 27, or 13.2 per cent, from other respiratory diseases. Of the deaths from all causes among stone workers in Vermont, 52.4 per cent were attributed either to pulmonary tuberculosis or to other respiratory diseases.

The census mortality statistics for 1900 combine marble and stone cutters into one group, including 26,141 males aged 15 years and over in the registration States. Of the number stated, 659, or 2.5 per cent, had attained to 65 years of age or over, which compares with 3.9 per cent for men in mechanical and manufacturing industries generally. In the mortality from all causes the death rate is comparatively low at ages under 25, but high at ages 25 and over, as shown in detail in Table 75. The census mortality statistics, however, are subject to the criticism that in all probability the facts are understated on account of defective enumeration.

TABLE 75.—MORTALITY FROM ALL CAUSES AMONG MARBLE AND STONE CUTTERS, COMPARED WITH THAT OF THE MANUFACTURING AND MECHANICAL CLASS AND THE MERCANTILE AND TRADING CLASS, IN THE REGISTRATION STATES, 1900, BY AGE GROUPS.

[Source: Report of the Bureau of the Census on Vital Statistics, 1900.]

Age at death.	Death rate per 1,000 among—		
	Marble and stone cutters.	The manufacturing and mechanical class.	The mercantile and trading class.
15 to 24 years	3.35	4.43	2.60
25 to 44 years	9.32	8.35	6.72
45 to 64 years	24.72	20.16	19.91
65 years and over	122.91	105.43	93.79

A further difficulty in connection with the vital statistics of stone and marble cutters results from the fact that men in this trade are a very mobile element, frequently moving from one place to another in response to better trade conditions, higher wages, etc., in other fields. The most suggestive result of the census mortality investigation is the extraordinarily high death rate from pulmonary tuberculosis, which is returned at 5.41 per 1,000, compared with 2.62 for the mechanical and manufacturing class, and 1.66 for the mercantile and trading class.

ENGLISH OCCUPATIONAL MORTALITY INVESTIGATIONS.

For unknown reasons the Report of the Registrar-General for England and Wales does not specifically consider stonecutters, but combines them with quarrymen in stone and slate, which, of course, precludes the utility of the resulting averages in an effort to determine the relative degree of pulmonary tuberculosis frequency in a well-defined specific occupation such as the stonecutters' trade. Even when considered as a group, however, quarrymen and stonecutters combined, according to English statistics, show an excessive mortality from pulmonary tuberculosis and other respiratory diseases, but it is a matter of regret that the data should not be separately available for men employed in the more important branches of the stone industry.

The health and mortality of men employed in granite, marble, and stone quarrying, including stonecutters and polishers, has been reported upon at length by Arlidge, who observes, in part, that—

> All employed on these mineral substances suffer in various degrees with respiratory disorders, and, on the whole, more so than coal miners. The quality of the stone, in regard to its petrological characters, determines its severity of action; but observations have hitherto not been sufficiently numerous to establish the fixed relations between the character of the stone and the mischief caused by its dust. Speaking generally, sedimentary rocks composed of siliceous and readily detached particles do more harm on inhalation than primary rocks in which a fusion of their constituents has taken place. Other modifying characters are exhibited in the chemical composition and in the miscibility of the mineral dust with fluid.

MORTALITY OF THE GRANITE CUTTERS OF ABERDEEN.

With special reference to granite cutting in the district of Aberdeen, Scotland, it is stated that men employed in the cutting, dressing, and polishing of granite are seldom victims of pulmonary lesions attributable to their occupation. Arlidge considers this a surprising fact, possibly explained by the density of granite and its lithological elements. He quotes Prof. Hamilton, of Aberdeen University, to the effect that the explanation may be found in the igneous character of the rock, which opposes itself to the throwing off of dust, because its particles, unlike those of stratified rocks, do not exist in granite ready formed, but must be made by the chisel of the workman. Prof. Hamilton concludes that—

> The dust in granite working would in all likelihood be coarser than in chiseling stratified rock, and would be caught in the superior respiratory passages without gaining entrance to the air vesicles where alone it seems to make its way into the pulmonary lymphatics.

Whether this explanation is accepted or not, it is a fact of considerable importance that the men employed in the granite-cutting industries suffer considerably from chronic bronchitis, but the severe lesions indicative of fibrosis and industrial phthisis are practically unknown among them.

According to the report of the chief inspector of factories for 1880 (p. 81)—

> It seems that a like immunity is enjoyed by the laborers in the Purbeck and Portland quarries. Here the material is a limestone of close, compact grain, and not a mass of imperfectly coherent particles of sand; in short, a marble—a substance recognized by those who work it as but slightly detrimental to the respiratory organs.

In marked contrast, Arlidge directs attention to the extremely high fatality rate among men employed in the Edinburgh stone quarries, but no conclusive statistical information has been made public concerning this. According to Dr. R. W. Philip, of Edinburgh, in a statement to Dr. Arlidge, "A large number of cases of stonemasons suffering from phthisis seek relief at the local dispensary, and the average age at which they come under observation is only about 35 years. As a rule, the cases run a very chronic course, passing from recurrent to persistent attacks of bronchitis." Reference is made to a much earlier observation by Prof. Alison in 1824, according to which there was reason to believe "that there was hardly an instance of a mason regularly employed in hewing stones in Edinburgh being free from phthisical symptoms to the age of 50."

COMPARATIVE OCCUPATIONAL MORTALITY OF THE STONE WORKERS OF ABERDEEN.

It is self-evident that these conflicting conclusions are more or less attributable to important variations in the nature of the stone quarried as well as to differences in the method of work. Modern pneumatic processes, for illustration, have practically revolutionized the stone-cutting industry, and the dust menace has been very materially increased in consequence. The mortality of stone workers in the Aberdeen district has been reported upon with admirable thoroughness by Dr. Matthew Hay in an appendix to his annual report as medical officer of health for the year 1909. He points out that—

A workman who has contracted phthisis in one occupation may change his occupation some months or years before death, and his relatives on registering his death may or may not give his original occupation as his ordinary occupation. Much depends upon the length and nature of the last occupation, whether it is presumed to be inferior or not, and on the person to whom it may fall to supply the information required by the registrar. Even the registrars themselves act differently in such cases of changed occupation.

Other difficulties are the probable incompleteness of returns regarding the number of persons employed, which by inference suggests the possibly greater practical utility and scientific conclusiveness of proportionate mortality data. Hay points out that—

> Considerable interest attaches in Aberdeen to the incidence of phthisis among stonecutters and masons, owing to their considerable number and to the danger to which they are exposed from the inhalation of granite dust. All masons are not, however, so exposed, as a proportion of them, varying with the character of the building, are employed solely in building, and are known within the trade as "wallers," while the remainder are engaged in hewing and dressing stones. Wallers are not so distinguished in the death registers. Nor is any distinction made in the registers between masons, whether hewers or wallers, employed in connection with buildings and stonecutters employed in the numerous monumental yards. As a rule, a hewer working in the latter is known as a stonecutter, but he is not infrequently designated as a mason.

The results of the investigation are summarized in Table 76.

TABLE 76.—AVERAGE ANNUAL DEATH RATE OF PERSONS 21 YEARS OF AGE AND OVER (EXCLUDING EMPLOYERS) IN ABERDEEN, 1900 TO 1909, BY OCCUPATIONS.

Occupation.	Estimated average annual number of persons over 21 years of age employed.	Annual number of deaths per 1,000 persons due to—							
		Phthisis.	Lung diseases.		Circulatory and nervous diseases.	Other diseases.	All causes.	Tuberculosis.	
			Excluding phthisis.	Including phthisis.				Wives and widows.	Unmarried children.
MALES.									
Stonecutters and masons	1,750	5.7	2.5	8.2	4.6	5.4	18.1	1.8	4.7
Stone polishers	420	2.5	4.8	7.3	4.8	5.2	17.3	1.6	5.5
Joiners, etc	1,420	1.8	3.4	5.2	7.0	8.6	20.8	1.8	3.7
Painters	420	2.1	4.0	6.1	9.3	5.2	20.7	1.7	4.5
Tailors	620	3.2	5.6	8.8	9.0	8.5	26.5	1.6	2.7
Bakers	360	1.4	4.4	5.8	6.4	8.3	20.6	1.9	4.4
Engineers, etc	2,600	1.8	2.3	4.1	5.2	4.8	14.1	1.6	3.9
Printers, etc	380	4.5	1.1	5.6	4.5	3.7	13.7	1.1	1.6
Comb makers	345	4.3	4.3	8.6	7.2	6.7	22.5	2.0	3.2
Carters	1,450	1.1	3.1	4.2	3.0	5.0	12.2	1.8	4.7
Laborers	3,600	2.3	5.6	7.9	8.3	9.8	26.0	2.1	4.4
Clerks	1,220	3.8	1.5	5.3	3.9	5.4	14.6	1.1	.7
FEMALES.									
Dressmakers and milliners	1,750	1.9	1.5	3.4	2.7	3.3	9.4	....	....
Domestic servants	3,500	2.1	3.3	5.4	6.8	8.8	21.1	....	....
All males 21 years and over	....	1.9	3.3	5.2	5.6	8.0	18.8	....	....
All females 21 years and over	....	1.7	2.7	4.4	5.1	8.3	17.8	....	....

This table is of additional interest in that it includes a number of other important occupations with more or less exposure to industrial dust. The table shows that stonecutters and masons rank above all other employments considered, with a death rate of 5.7 per 1,000 from phthisis, which is three times as high as the average of 1.9 for males above 21 years of age. Making allowance for persons not directly employed in the cutting and hewing of granite, it is quite probable that the true phthisis death rate of this class is 6.2 per 1,000. Next to stone workers, according to the table, come printers and lithographers, with a phthisis mortality of 4.5 per 1,000, which is slightly less than two and one-half times the average. In further explanation of the table it is said that—

> As a rule, occupations with a high mortality from phthisis have also an increased mortality from other lung diseases. This is not the case with stonecutters and masons in Aberdeen, or with printers and lithographers, or with clerks. In all three occupations, the mortality from other lung diseases is under the average. Tailors and comb makers, however, follow the usual rule, having a somewhat high mortality from other lung diseases. The result is that, if the rates for phthisis and other lung diseases are combined, tailors and comb makers, with 8.8 and 8.6 per 1,000, respectively, take precedence of stonecutters and printers, with 8.2 and 5.6, respectively. For clerks it is 5.3. Indeed, the total death rate from lung diseases (including phthisis) among clerks and printers is only very slightly beyond the average (5.2) for all male persons above 21 years of age.
>
> Some of these differences in the incidence of phthisis and of other lung diseases are probably in some measure more apparent than real, being dependent upon the fact that the death rate from phthisis decreases after the age of 55 to 60, while the death rate from other lung diseases rapidly increases with advancing age. Occupations with a large proportion of old men have accordingly a lower death rate from phthisis and a higher death rate from other lung diseases than occupations with a smaller proportion of old men.

Attention is directed to the exceptionally large number of deaths from phthisis among stonecutters after the age of 55, which is a relatively rare occurrence in other occupations. The rather involved terminology of English occupational terms precludes an accurate comparison with corresponding statistics for this country. Two occupations which show high death rates from phthisis in the Aberdeen experience, namely, stonecutting and comb making, are both referred to as dusty occupations, and there are grounds for believing, not only from available statistics but from results of similar investigations elsewhere, that the dust was the slow but ultimate cause of death in many cases.

PHTHISIS, AND PNEUMATIC TOOLS.

The subject of stonecutters' mortality in relation to the use of pneumatic tools is considered briefly by Hay, who points out that—

In regard to the mortality from phthisis among stonecutters and masons, the question has been raised as to whether the introduction of pneumatically driven tools, which produce more fine dust than the old hand chisels, has increased the amount of phthisis and lung disease. I am informed that previous to 1900 very few pneumatic tools were in use in Aberdeen. Between 1900 and 1905, and especially after 1902, their use rapidly extended, so that by 1905 they had come into full use in practically all stonecutting yards.

The following table gives the number of deaths among stonecutters and masons combined for each of the 15 years ending with 1909. The first five years, 1895–1899, represent a period in which pneumatic tools were coming into use; and the third five years, 1905–1909, a period in which the tools were in full use. Only deaths at ages of 21 years and upward are included.

TABLE 77.—NUMBER OF DEATHS FROM PHTHISIS AND FROM OTHER LUNG DISEASES AMONG STONECUTTERS AND MASONS OF ABERDEEN, 1895 TO 1909.

Year and period.	Cause of death.	
	Phthisis.	Other lung diseases.
First period:		
1895	6	5
1896	9	1
1897	12	5
1898	7	9
1899	13	8
Total	47	28
Second period:		
1900	10	6
1901	6	10
1902	13	5
1903	12	2
1904	9	8
Total	50	31
Third period:		
1905	11	2
1906	10	3
1907	9	3
1908	11	1
1909	8	3
Total	49	12

The numbers for 1900–1904 are slightly above those for 1895–1899 in respect both of phthisis and of other lung diseases. The total number for 1905–1909 is, however, considerably down; but the fall is practically confined to deaths from lung diseases other than phthisis.

The first two periods are fairly comparable, except that allowance should be made for an increase of, perhaps, 10 per cent in the number of persons employed as between the first and second periods, and for the fact that during the two periods the mortality from phthisis in the community as a whole was falling. As probably the effect of the latter influence did rather more than equalize the effect of the former, a comparison of the first two periods would appear to show that the introduction of pneumatic tools had produced some increase, although not a large increase, in the death rate from phthisis and other lung diseases.

As regards the third period (1905–1909), while the number of stonecutters and masons employed in monumental yards has not fallen off, but rather increased, there has been a great decline in the number of building masons in employment, due to unusual depression in the building trade. Some of these out of employment as mason hewers have, I believe, found employment as stonecutters in monumental yards, and thus checked in some measure the advance-ment of apprentices to the status of journeyman. Some have emigrated to America. Some have drifted into laboring, but not improbably in the event of death within two or three years of leaving their trade, their deaths have been registered by their relatives as the deaths of masons. It is difficult to know to what extent to make allowance for these disturbing factors. Probably, any reasonable allowance would not raise the total number of deaths from phthisis and other lung diseases combined above or even up to the number for each of the preceding two quinquennial periods, but it would raise the number of deaths from phthisis above the numbers for these periods.

After a brief discussion of possible errors attributable to the erroneous use of apparently equivalent occupational terms, it is said with further reference to the use of pneumatic tools, that—

> About the time of the introduction of pneumatic tools for granite cutting, but not altogether as a consequence of it, the sheds, which had usually been entirely open along the front, as in the case of an ordinary builder's shed, began to be closed. The closure, while increasing the liability to the inhalation of dust, must at the same time have afforded some protection against cold and possible chills. This may possibly account in part for the diminution during the past five years in the number of lung diseases other than phthisis. But the numbers dealt with are small, and allowance must be made for mere chance variations.

COMPARATIVE FREQUENCY OF LUNG DISEASES IN ABERDEEN AND IN EDINBURGH.

In view of the foregoing, the final conclusion is advanced that "the unusual combination, in the case of workers in stone, of a high mortality from phthisis, with a low mortality from lung diseases other than phthisis, may serve to bear out the statement made by the late Prof. Hamilton, professor of pathology in Aberdeen, that a definite development of so-called lithosis, or a fibroid affection of the lungs due to stone dust, is rare among granite workers, although common among firestone workers in Edinburgh." In part, this conclusion would seem to be sustained by the examination of a relatively small number of autopsy records. The strictly medical question, therefore, whether the form of tuberculosis met with among the granite workers of Aberdeen was to be considered industrial fibrosis with a superinduced tuberculosis, or strictly pulmonary tuberculosis in the more limited sense of the term, can not be considered finally decided by the information at present available. The investigation reemphasizes earlier conclusions regarding the importance of minute attention to the character of the dust inhaled in the different branches of the stone industry; certain forms of stone dust are obviously much more injurious than others, and a general grouping of stone workers for purposes of mortality analysis is therefore quite likely to yield inconclusive results.

PHYSIQUE OF STONE WORKERS.

Not only is it necessary to take into account the kind and nature of the dust inhaled, particularly whether of granite trap rock, sandstone, or limestone, but the different employments also require special consideration. Some occupations are unquestionably very much more exposed than others. Additional attention is necessary as regards the conditions of employment, whether outdoors or indoors, and finally, there is the important relation of physique to disease resistance. Table 78 shows the average chest expansion of males in certain occupations, including the Aberdeen granite trade, and has been derived from the discussion on industrial pneumoconiosis, by E. L. Collis, London, 1915, in the Milroy Lectures.

TABLE 78.—AVERAGE CHEST EXPANSION IN INCHES OF MALES IN CERTAIN CLASSES, AT VARIOUS AGE PERIODS.

Age period.	Leisured class.	Factory operatives not exposed to dust.	Aberdeen granite trade.			Sheffield cutlery trade.			Strippers of cotton carding machines.
			Polishers, etc., very slightly exposed to dust.	Cutters in open sheds.	Cutters in closed sheds.	Cutters.	Light grinders.	Heavy grinders.	
14	2.31	....	2.58	2.14	2.40	2.43	2.54	2.67	3.33
17	2.45	....	2.57	2.64	2.60	2.27	2.37	2.49	
20	2.79	2.84	2.58	2.43	2.44	2.24	2.45	2.19	2.75
25	2.90	2.33	2.21	2.51	2.11	1.96	2.40	2.19	2.45
30	2.87	2.13	2.14	2.19	1.93	2.09	2.14	2.04	
35	2.64	2.20	2.04	2.13	1.80	1.92	2.07	1.89	1.86
40	2.35	2.15	2.07	2.16	1.67	1.73	1.75	1.52	
45	2.39	2.24	1.98	1.92	1.84	1.56	1.58	1.55	1.69
50	2.24	1.64	2.04	1.73	1.44	1.49	1.58	1.51	
55	2.12	....	1.80	....	1.56	1.50	1.53	1.45	1.72
65 and over	1.87	....	....	....	....	1.13	....	....	

In connection with the table Dr. Collis points out that—

Inhalation of silica dust takes several years, varying with the intensity of the exposure, in producing any obvious effect, but gradually the affected person notices that on exertion his breathing capacity has become limited, and that a cough, slight at first, has become persistent, though seldom accompanied by much expectoration; otherwise he may look robust and feel well. This limitation in the breathing capacity which has been noted by nearly every authority from Hippocrates to the South African Miners' Phthisis Commission of 1912 has been described as pathognomic of the disease and may at first be the only objective sign present. In several inquiries in which some thousands of operatives have been examined, I have collected physical data which demonstrate this limitation, and the results are stated in the table; but as Dr. Cumpston points out, "the actual amount of expansion in inches is not of so much importance as the manner in which the chest wall behaves when an attempt at expansion is made." This diminution in chest expansion must, however, not be relied on as an indication of exposure to silica dust, as it is present, though not so markedly, among workers exposed to other dusts.

In further explanation, it is said that should the condition progress until the age of 45 to 50 years, a definite clinical picture is presented, briefly described as follows:

Such a man is usually somewhat below the average height for his class, for exposure to dust inhalation during the growing period of life appears to inhibit the normal growth; he looks well, but if he has just ascended stairs or has hurried, he is out of breath for a few minutes; and on being questioned, though unable to count 20 without taking a breath, he speaks of himself as fit, and may even boast of being a credit to his trade; but he owns to frequent colds, especially in winter, and a troublesome cough; he expectorates but little sputum, and what there is is rejected with difficulty and is colored by the dust produced in his work; in some industries, particularly in tin mining and gold mining, he is stated to be subject to distinctive attacks of dyspnœa, but this symptom is not prevalent among metal grinders or granite cutters. When he is stripped he is found to be well nourished, but respiration is seen to be carried on nearly entirely by diaphragmatic action, and even though urged he seems incapable of inducing his intercostal muscles to lift his ribs.

PRACTICAL VALUE OF PHYSICAL EXAMINATIONS.

These observations, arrived at after an exceedingly careful and conservative study of the subject, emphasize strongly the great practical value of physical examinations, and reexaminations at least once a year. The necessity for such an examination, including a radiological photograph of the chest, becomes of supreme importance in the case of men exposed to the risk of silica or quartz dust inhalation, particularly in confined spaces, such as stopes of deep mines, etc., for, as previously intimated, the general appearance and general indications of health and strength may be very deceptive, since the progress of the disease is often extremely chronic, lasting in some cases, according to Wheatley, "upwards of 20 years." Knowledge of the exact occupation followed is, therefore, of equal importance and general conclusions, based upon groups of men in different specific employments, though following the same trade, can not be relied on as trustworthy. According to Collis—

Silica dust is generated in the following among other industries: Gold mining, tin mining, and lead mining; quarrying and dressing sandstone and granite; flint knapping, making honing stones for scythes; building millstones, which are used and require dressing in such diverse industries as the milling of flour, rice, cocoa, cement (occasionally), and white lead; the manufacture of grindstones, which are used and require racing, trueing, and surfacing in the grinding of metal articles, mother-of-pearl, bone, horn, and other materials; sand blasting to clean castings and to etch glass; crushing flints and quartz to make silica flour used in the manufacture of pottery, certain abrasive soaps, sandpapers, chicken food, disinfecting powders, and silica paints; the mining and quarrying of ganister and silica stone; and the manufacture of silica bricks.

DESCRIPTIVE ACCOUNT OF SILICA OR QUARTZ.

Pure silica, or the oxide of silicon, is the substance commonly known as quartz, which is one of the most abundant of mineral substances. According to Frank J. Katz, in a report on "The Production of Silica in 1913," to the United States Geological Survey—

> Its occurrences of commercial importance are in a great many different forms, such as vein quartz; as a constituent of pegmatites; as sand, sandstone, quartzite, or flint; as tripoli; and as diatomaceous (infusorial) earth. In some forms, such as rose, smoky, and amethystine quartz, it has a gem value. This chapter deals with silica from all sources exclusive of gem quartz, of all forms of silica used for making glass, and also of all silica used in the form of sand, gravel, and crushed material for building, for concrete and mortar, for foundry and furnace work, and for cutting and grinding stone.

As regards the principal uses of silica, it may be said, in the words of the same authority, that silica is employed in the manufacture of pottery, paints, scouring soaps, as a wood filler, and as a polisher. In pottery the use of silica, generally called flint in the pottery industry, diminishes the shrinkage in the body of the ware; it is also used in many glazes. Silica for use in pottery should contain less than 0.5 per cent of iron-bearing minerals. Considerable quantities of very finely ground silica are used in the manufacture of paint. In all of these processes it is self-evident that exposure to the inhalation of silica or quartz dust must directly or indirectly result in serious disease complications. The exact proportion of pure silica in the dust inhaled should be ascertained in all cases where an effort is made to establish with accuracy the health-injurious conditions of an occupation with exposure to mineral dust.

SUGGESTIONS FOR PROTECTIVE PRECAUTIONS.

It is regrettable that no very extensive investigations should have been made into the health-injurious conditions of the more important branches of the American stone industry. Hanson, in his report on "Methods of Protection from Dusts and Fumes," illustrates the process of stonecutting and observes that—

> The strong blast of air keeps the granite clean, but gives rise to a great amount of dust. The surfacing tool is either a large hammer or an instrument which presents four smaller separate faces. Sometimes a bushing hammer made of thin, chisel-like blades bolted together is used; this creates the finest dust of all. The men who operate the surfacing tools rarely wear masks. Some protect themselves from flying chips by means of wire screens placed about the hammer, some wear wire masks, and some wear glasses.

This is an admirable description of modern processes which, on account of the extensive use of pneumatic tools, have become extremely injurious in numerous individual cases. Only superficial precautions, as a rule, are adopted. The regulations of the Barre branch of the Granite Manufacturers' Association, for illustration, provide:

Article 6. Cutters must provide themselves with broom, and no air power to be used to remove dust.

Article 7. Turning down grindstones to be done outside of working hours, unless said stones are thoroughly boxed in. This agreement is made for the purpose of eliminating the dust from grindstones.

Article 8. No surface-cutting machine to be worked in cutting shed during working hours, unless properly equipped with effective air suction or other device to remove dust. Hand surfacers shall not weigh more thau 12 pounds. Workmen to be amply protected at all times from dust from said machines, whether iu the sheds or outside. This article not to apply to pneumatic tools weighing less than 7 pouuds.

As a matter of fact, however, there is only inadequate protection from dust at most of the machines and in most of the sheds which have been investigated and reported upon, including the Barre district of Vermont.

INJURIOUS OCCUPATIONAL CONDITIONS.

The occupation is also briefly referred to in a recent discussion by Baker,[1] in part as follows:

> Much of the stonecutting is outdoors or in large, airy sheds. It consists of shaping, smoothing, and cutting the stones into smaller pieces, as for paving blocks. Formerly much of the work was done by hand, but now pneumatic tools are used considerably. These produce a finer dust and tend to increase the hazard. It is held by some that the dangers are greater in sedimentary stones than the harder stones, like granite, but no definite figures on this point could be obtained. Dust is also stirred up in sweeping and moving the stones about. Thirty-seven stonecutters were medically and physically examined, and of this number 12 patients showed respiratory disease, 9 being ill with chronic and 3 with acute diseases. Three workers had pulmonary tuberculosis, three emphysema, and one each chronic bronchitis, chronic pharyngitis, chalicosis, acute bronchitis, acute pharyngitis, and acute laryngitis. Although only one case of chalicosis is recorded, a greater number would probably have been noted if other factors were studied as closely as physical signs.

In view of the fact that 21 of the stonecutters were over 40 years of age, the number ascertained to be affected with pulmonary tuberculosis is relatively small, but the number affected with respiratory diseases more or less predisposing to a terminal tuberculosis must be considered very large. There is no information as to the kind of dust inhaled or the nature of the stone cut. The sanitary conditions of the shed were obviously far from what they should have been.

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[1] Journal American Medical Association, May 6, 1916.

URGENCY OF DRASTIC REGULATIONS.

The importance and necessity of drastic regulations in stonecutting, polishing, etc., have not been recognized in the factory legislation of this country. In the Edinburgh and Aberdeen districts of Scotland the local inspectors, according to the annual report of the chief inspector of factories and workshops for 1910—

> have been pressing upon the granite cutters the question of local exhaust. The pneumatic tools which are now universally used have largely increased the amount of fine dust breathed by the workers. Mr. Buchan says some idea of the action of granite dust can be gathered from the fact that the glasses of the workers' goggles become so dim by the constant impact of the fine particles of granite that monthly renewal is essential. Mr. Kirkwood says experiment has led to the successful removal of dust at the point of the tool by the induced draft, but he fears that the extra fitting with a pipe attached on the side of the tool may cause difficulties in the manipulation at fine work. One occupier has, however, undertaken to give the arrangement a fair trial, and the workers seem anxious that something should be done.

PRACTICAL POSSIBILITIES OF DUST PREVENTION.

There are abundant reasons for believing that much more could be done to control the dust menace in the stonecutting industry than is at present being done in practically all American stonecutting districts. W. Gilman Thompson refers to the statistics of the Quincy, Mass., district for the year 1907, according to which 41 per cent of the deaths of stonecutters were from pulmonary tuberculosis, and including all forms of pulmonary disease the proportion was 53 per cent. According to the same investigation, the tuberculosis mortality among stone and marble cutters and carvers was found to be five times greater than among farmers or lumbermen. The usual processes are explained and admirably illustrated in the work of W. Gilman Thompson, who observes, in part, as follows:

> The drilling of rocks and coal or mineral veins for blasting is almost universally accomplished by machine drill hammers, operated by compressed air or steam, which have replaced the slow method with the crowbar and hand-wielded sledge hammer. When this process is conducted by machines in mines, tunnel boring, or any kind of hard dry stone without the use of a water spray to moisten the dust, it is one of the most dangerous of all the trades which produce chronic disease. When the drilling is done overhead, so that the dust falls back toward the face of the machine operator, the hazard is at its worst.

These observations apply in a large measure to rock drilling in mines, tunnels, etc. In coal mining where the overlying strata are usually of limestone, the dust menace is, of course, much less than in deep mining where the quartz rock consists frequently of almost pure silica. According to W. Gilman Thompson—

> To lessen the dust hazard from the drill holes various expedients have been devised. The simplest of these is the placing of wet cloths around the drill hole to catch the dust and mopping up the dust, procedures which are troublesome and time consuming. A recent invention consists of a pipe attached to the drill at the mouth of the bore through which a fine jet of water is forced under pressure into the drill hole, where it unites with the compression air stream in mixing the dust into a harmless paste which flows back out of the hole. Another invention by Korfmann employs an exhaust pipe connected with the drill, by means of which the dust is drawn out of the hole, after the manner of a vacuum cleaner, and discharged into a vessel of water or a moist bag. These inventions have the advantage that they operate independently of the workmen and do not require precautions, which such workmen are notoriously reluctant to observe.

Actual experience has unfortunately shown many of these devices to be rather impracticable in that they cause too much interference with the work and consequently bring about a diminution in earnings. The use of dust-spraying devices, etc., as well as respirators in connection with exceptionally dusty processes where the dust consists largely of pure silica, should be made obligatory upon the employees as well as upon employers.

Although not directly pertinent to the present discussion, the following interesting reference to a case of Raynaud's disease[1] in a stonecutter using pneumatic tools has been reported by Dr. Charles H. Cargile, of Bentonville, Ark.:

> D. E. F., aged 26, married, with good family and personal history, except that he was neurotic, found that frequently and only when cutting stone with a pneumatic tool the index and middle fingers of his right hand would become white, cold, and numb. This instrument, which oscillates from 900 to 1,600 times per minute, transmits strong vibrations to the hand of the operator. The patient told me of a fellow laborer who was similarly affected by using the same kind of tool.

Whether there is a well-defined occupational relation between stone cutting and the occurrence of Raynaud's disease has not been sufficiently investigated to justify definite conclusions at the present time.

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[1] Raynaud's disease is defined by Gould and Pyle as: "A vascular disorder characterized by three grades of intensity: (*a*) *Local syncope*, observed most frequently in the extremities, and producing the condition known as dead fingers or dead toes; it is analogous to that produced by intense cold. (*b*) *Local asphyxia*, which usually follows local syncope, but may develop independently. Chilblains are the mildest manifestation of this condition. The fingers and toes and the ears are the parts usually affected. In the most extreme degree the parts are swollen, stiff and livid, and the capillary circulation is almost stagnant. (*c*) *Local symmetric gangrene*, the mildest form of which follows local asphyxia."

MORTALITY OF MARBLE AND STONE CUTTERS—UNITED STATES REGISTRATION AREA.

Most of the preceding observations have been derived from foreign sources. The census statistics for 1900 can hardly be considered applicable to present conditions, nor are they conclusive regarding the different branches of the stone industry and the more specific occupations followed.

The mortality of marble and stone cutters has been reported upon for the years 1908 and 1909 by the Division of Vital Statistics of the United States Census Bureau, but no subsequent information has been made public and the data are therefore limited to the two years referred to. According to the census report, out of 1,657 deaths of marble and stone cutters from all causes, 509, or 30.7 per cent, were from pulmonary tuberculosis. The details of the mortality by divisional periods of life are shown in Table 79.

TABLE 79.—PROPORTIONATE MORTALITY OF MARBLE AND STONE CUTTERS FROM PULMONARY TUBERCULOSIS, UNITED STATES REGISTRATION AREA, 1908 AND 1909.

Age at death.	Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent of deaths from all causes.
15 to 24 years	61	16	26.2
25 to 34 years	170	74	43.5
35 to 44 years	299	132	44.1
45 to 54 years	401	167	41.6
55 to 64 years	407	95	23.3
65 years and over	316	25	7.9
Age unknown	3	....	....
Total, 15 years and over	1,657	509	30.7

TABLE 80.—PROPORTIONATE MORTALITY OF MARBLE AND STONE CUTTERS FROM NONTUBERCULOUS RESPIRATORY DISEASES, UNITED STATES REGISTRATION AREA, 1908 AND 1909.

Cause of death.	Number of deaths.	Per cent of deaths from all causes.
Asthma	9	0.5
Bronchitis	29	1.8
Pneumonia	131	7.9
Other nontuberculous respiratory diseases	33	2.0
Total	202	12.2

TUBERCULOUS AND NONTUBERCULOUS LUNG DISEASES.

Tables 79 and 80 are of exceptional interest and value in that they may be considered representative for the American stone industry at the present time. There are no reasons for believing that material changes have occurred in the mortality during recent years. The data conclusively indicate an excessive proportionate mortality from pulmonary tuberculosis among marble and stone cutters at every divisional period of life. Commencing with ages 15 to 24 the proportion of deaths, 26.2 per cent, is not exceptionally high in comparison with other trades or occupations with continuous and considerable exposure to metallic or mineral dust. Among plasterers, for illustration, the corresponding proportion, according to data derived from the same official American sources, was 25 per cent, and for potters, 46.2 per cent, and for glassworkers, 47.2 per cent. At ages 25 to 34, however, the proportionate mortality from pulmonary tuberculosis among marble and stone cutters was 43.5 per cent, which compares with 31.5 per cent for plasterers, 44.4 per cent for potters, and 42.6 per cent for glassworkers. The proportion continues high throughout the remainder of life; for illustration, at ages 65 and over, among marble and stone cutters, 7.9 per cent are from pulmonary tuberculosis, compared with 3.8 per cent for potters, 4 per cent for glassworkers, and 3.6 per cent for plasterers. Aside from an excessive mortality from pulmonary tuberculosis the mortality from nontuberculous respiratory diseases among marble and stone cutters is extremely high, or 12.2 per cent for respiratory diseases considered as a group, or, respectively, 0.5 per cent for asthma, 1.8 per cent for bronchitis, 7.9 per cent for pneumonia, and 2.0 per cent for other respiratory diseases.

COMPARATIVE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASE—UNITED STATES REGISTRATION AREA.

On account of the exceptional importance of nontuberculous respiratory diseases among certain groups of occupations with continuous and considerable exposure to mineral dust the following comparison is included in the present discussion:

TABLE 81.—COMPARATIVE PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES IN SPECIFIED OCCUPATIONS EXPOSED TO MINERAL DUST, UNITED STATES REGISTRATION AREA, 1908 AND 1909.

Cause of death.	Per cent of deaths due to each specific cause among—			
	Marble and stone cutters.	Potters.	Glassworkers.	Plasterers.
Asthma	0.5	0.7	0.2	0.3
Bronchitis	1.8	.7	.6	1.1
Pneumonia	7.9	6.7	7.7	8.1
Other nontuberculous respiratory diseases	2.0	4.4	.7	1.1
Total	12.2	12.5	9.2	10.6
All other causes	87.8	87.5	90.8	89.4
Total, all causes	100.0	100.0	100.0	100.0

Table 81 brings out the interesting fact that the proportionate mortality from bronchitis is particularly excessive among marble and stone cutters in comparison with other occupations with exposure to mineral dust, and with the exception of potters the conclusion applies equally to asthma and other respiratory diseases, excepting pneumonia. The data are not sufficient for final conclusions, but they suggest the practical value of thoroughly specialized investigations into the occurrence of nontuberculous respiratory diseases among marble and stone workers, particularly asthma and bronchitis. The data are derived from official American vital statistics and are quite generally confirmed by corresponding statistics derived from insurance experience or foreign sources.

MORTALITY OF JOURNEYMEN STONECUTTERS—MEDICO-ACTUARIAL EXPERIENCE.

In the medico-actuarial investigation journeymen stonecutters were fortunately considered separately, and the results, based upon a fairly extensive experience, indicate a truly lamentable condition. In the interpretation of Table 82 it should be taken into consideration that only the better class of stonecutters would be accepted for ordinary life insurance, since in former years at least quite generally the practice was to decline stone workers entirely.

TABLE 82.—MORTALITY FROM ALL CAUSES AMONG JOURNEYMEN STONECUTTERS, BY AGE GROUPS—MEDICO-ACTUARIAL INVESTIGATION.

Age at death.	Number exposed to risk 1 year.	Actual deaths.	Expected deaths.	Per cent actual are of expected deaths.
15 to 29 years	2,579	17	11.96	142
30 to 39 years	2,289	32	13.44	238
40 to 49 years	681	22	6.75	326
50 to 59 years	138	5	3.20	156
60 years and over	3	....	.10	....
Total, 15 years and over	5,690	76	35.45	214

According to this table the actual mortality of journeymen stonecutters in the combined experience of American life insurance companies is 214 per cent of the expected, increasing rapidly with age to a maximum of 326 per cent at ages 40 to 49. The table, of course, includes all causes, and does not refer to pulmonary tuberculosis, but, as subsequently to be shown, the excess in the mortality is chiefly attributable to this disease. Out of 76 deaths at all ages of journeymen stonecutters not a single death occurred at ages 60 and over. This, of course, in part may possibly be the result of the limited extent of the experience under consideration.

MORTALITY OF MARBLE AND STONE WORKERS—INDUSTRIAL INSURANCE EXPERIENCE.

According to Table 83, the industrial mortality experience of the Prudential Co. with reference to marble and stone workers for the period 1897 to 1914 includes 2,052 deaths from all causes, of which 690, or 33.6 per cent, are from pulmonary tuberculosis.

TABLE 83.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG MARBLE AND STONE WORKERS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, COMPARED WITH THAT OF ALL MALES IN UNITED STATES REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of marble and stone workers, 1897 to 1914, from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Marble and stone workers.	Males in registration area, 1900 to 1913.
15 to 24 years	60	23	38.3	27.0
25 to 34 years	228	121	53.1	30.5
35 to 44 years	403	179	44.4	23.4
45 to 54 years	513	200	39.0	14.7
55 to 64 years	506	135	26.7	7.9
65 years and over	342	32	9.4	2.6
Total, 15 years and over	2,052	690	33.6	13.9

The proportionate mortality from pulmonary tuberculosis is extremely high at all ages, but particularly so at ages 25 to 34, at which out of the mortality from all causes 53.1 per cent was from pulmonary tuberculosis, against 30.5 per cent among males in the registration area. If it had been possible to separate this experience according to the different branches of the stone industry and the more important occupations with dust exposure, there are the most convincing reasons for believing that the results of this analysis would have been decidedly more suggestive of the seriously health-injurious consequences of exposure to silica or quartz dust.

GENERAL CONCLUSIONS.

Inconclusive as these observations are with reference to the several branches of the stone industry and the more important specific occupations with dust exposure, the data are fully sufficient, for the present purpose, to emphasize the extremely dangerous nature of dust exposure in connection with practically all processes of stone quarrying, cutting, polishing, etc. This conclusion applies also and perhaps even more specifically to men employed in connection with stone-crushing operations, which during recent years have assumed very considerable proportions throughout the country. In practically all of these rock-crushing processes no protective devices whatsoever are employed. Most of the men, it is true, work often only for a portion of the year, and much of the labor is of an itinerant nature, so that the serious damage done to the lungs must frequently escape observation. On account of the extreme hardness of trap rock, virtually the equivalent of flint, it is a practical certainty that dust exposure in trap-rock crushing is very serious. The entire stone industry must be more thoroughly investigated for the purpose of ascertaining the most health-injurious processes as well as such branches as include work on limestone and similar mineral substances apparently much less injurious than the so-called gritstone or granites, etc. In view, however, of the universal use of pneumatic tools in the stonecutting industry this aspect demands particular consideration for the ascertainment of the required methods and means by which the dust menace may be reduced to a minimum.[1]

The most recent medical observations on the mortality of stonecutters and marble workers are by Kober and Hanson in their treatise on Diseases of Occupation and Vocational Hygiene, where it is said, in part, that—

> We know now that the inhalation of mineral dust develops sooner or later pneumoconiosis which may eventuate in pulmonary tuberculosis. It is generally held that the liability to diseases of the respiratory passages is less in the case of paving stonecutters and slate splitters, and in the sawing, grinding, polishing, and lathe work which can be conducted by the wet process, than in the case of monument or custom work, and particularly in the surfacing, carving, and cutting with pneumatic tools. The greatest amount of dust is evolved by the surfacing machines which are operated with compressed air. Of the various tools employed the bushing hammer creates the finest dust. Unfortunately, work with pneumatic tools can not be done by the wet process, as the pasty material created by a mixture of water and dust clogs up the tools. This work is usually done in large open sheds or in the yards, but even under such conditions the men are exposed to clouds of dust. The sawing of granite and marble into slabs, turning in lathes, and the final polishing can be conducted by the wet process; soapstone sawing and cutting for joints is frequently done dry and is attended with exposure to considerable dust.

Kober also refers to the fact that experience has shown that the mortality from pulmonary tuberculosis is generally excessive among workers in sandstone and relatively low among workers in limestone. No additional evidence, however, has been forthcoming in support of this point of view, which for practical reasons is one of considerable importance. The suggestions concerning the prevention of dust exposure in the stone industry as advanced by Kober are also quite inadequate for the purpose of the effective sanitary control of an industry which is so obviously injurious to health and life and with regard to which the evidence of a decided predisposition to pulmonary tuberculosis is incontrovertible and conclusive.

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[1] A useful treatise on the subject of rock excavation. Including observations on rocks and their properties, methods of hand and machine drilling, quarrying, open-cut excavating, tunneling, etc., is Rock Excavation, by H. P. Gillette, New York, 1907. Of more general value is a recent treatise on the Elements of Mining, by Geo. J. Young (New York, 1916), which includes observations in detail on rock breaking, but not with special reference to rock crushing for road-making purposes, which is the branch of the industry probably most injurious to health.

MARBLE WORKERS.

Marble workers constitute a distinctive and well-defined group of the stone industry, which it has seemed best to consider separately, though most of the general statistics appertaining to the occupation are included in the stone industry considered as a whole. The American marble industry is centered chiefly in Vermont, where about 60 per cent of all the marble produced in the United States is quarried, and most of it is cut and dressed, sawed, or polished, as the case may be, in the locality where quarried. The Vermont State board of health for some six years (1900 to 1905, inclusive) reported the mortality by occupations, and of the 42 deaths of marble workers from all causes reported in that State only 5 were from pulmonary tuberculosis and 5 from other respiratory diseases. The fact that Vermont is an otherwise exceptionally healthful State goes far to mitigate the intrinsic dangers of the occupation resulting from continuous exposure to the inhalation of stone dust.

Bertillon, in his observations on morbidity and mortality, refers to stonecutters and workers in marble in Switzerland as being subject to a considerable mortality, principally from phthisis, which rapidly increases with age. Under 20 years of age, according to this authority, the mortality is lower than among the mass of the population. From 20 to 29 the death rate equals the average, from 30 to 39 it is twice, from 40 to 49 it is thrice, and from 50 to 59 it is four times the average rate of the Swiss as a nation. He also refers to Italian statistics, which are significant on account of the remarkable development of the marble industry at Carrara, stating that stonecutters and pavers average fewer days of sickness than the whole population up to 45 years, but considerably more above that age. In Paris the workers in marble are subject to a high death rate at all ages.

A very instructive descriptive account of the machine process as generally employed in the marble industry was included in the report on the stone industry for 1908, by Mr. W. C. Day, of the United States Geological Survey, from which the following extract is made as emphasizing the more or less health-injurious circumstances of employment in marble manufacture:

> After being sawed the slabs are placed on a "rubbing bed," which consists of a circular cast-iron plate, from 8 to 15 feet in diameter, the older forms having a circular opening from 1 foot to 18 inches

in diameter in the center. The plate is planed to a smooth surface and is mounted upon running gear so that it may revolve in a horizontal plane. Fixed arms, usually four in number, are sustained radially about one-fourth of an inch above the plate, either by an upright passing through the central opening or by a framework overhead (in the case of the newer solid forms of bed). The slabs of stone to be polished are placed upon the bed in front of the arms, and the bed is revolved slowly beneath them in such a direction as to hold them firmly against the arms. An abrading material, such as sand, sometimes mixed with "chilled shot," or crushed steel, with a constant supply of water, is fed upon the plate. If necessary, the stones are weighted to increase the friction. From this rubbing bed the slabs are removed to the emery bed, which is similar to the former, fine emery being used for abrasion. They are then rubbed down by hand with a fine, evenly grained sandstone, commonly called a "Scotch hone," with a sufficient supply of water, and smoothed off with pumice stone and water. The final polish is put on by rubbing the slabs upon a buffing bed, similar in form to the rubbing bed, but covered with a thick, specially prepared felt, upon which a small amount of "putty powder" (oxide of tin) is fed, to give a high gloss. The hand process consists in grinding on the rubbing bed as before, and then rubbing down by hand successively with Nova Scotia "blue stone," "red stone," "Scotch hone," and pumice stone, after which it is glossed with putty powder, or, in case of cheaper "onyxes" and common marbles, with a mixture of two parts of oxalic acid and one part of tin oxide.

In marble-cutting, as in the stone industry generally, the introduction of pneumatic tools operated by compressed air has brought in a new and decidedly health-injurious factor, since the amount of very fine dust generated by this process is much greater than when the work is done entirely by hand with the ordinary chisel and mallet. Portable stone-dressing machines have been invented and quite widely adopted, since in part the quality of the work done by these machines is superior to handwork, while the productive capacity is claimed to be from eight to fifteen times as much as when the work is done entirely by hand. Exhaust air is employed to keep the stone clean at the point of impact of the cutting tool, but the clouds of dust raised by this apparatus are considerable, even though the work is usually done outside of the shed. Aside from the dust generated in either machine or hand cutting, a vast additional amount of dust is produced during cleaning-up operations, and while labor organizations have, in part, provided against this risk by special regulations, the generation of much dust is practically unavoidable under the existing methods by which the work is carried on.

The United States census mortality statistics combine marble and stone cutters, so that it is impossible to separately consider statistically the mortality of this employment. As has been previously pointed out in discussing stonecutters generally, the evidence is entirely conclusive that the mortality from pulmonary tuberculosis and other respiratory diseases among this class is decidedly excessive. It is observed in a discussion of the mortality in the manufacturing and mechanical industries in the Report on Vital Statistics of the Census of 1890 (Part I, p. 144) that "it will be seen * * * that among marble and stone cutters in the United States the greatest proportion of deaths was due to pulmonary tuberculosis, being much greater than the average proportion due to this cause in this class. The proportion of deaths * * * due to diseases of the respiratory system was [also] greater." The respective death rates per 1,000 living were 3.15 for pulmonary tuberculosis for marble and stone cutters, against an average of 2.11 among occupied males in manufacturing and mechanical industries generally, and 1.91 for other respiratory diseases for marble and stone cutters against an average of 1.54.

The more general aspects of marble dust in relation to health, and with special reference to pulmonary tuberculosis, are considered in the discussion of the several branches of the mineral industries. The available data are unfortunately far from conclusive, but in a general way it would seem that marble dust is distinctly more injurious to health than the dust of limestone and slate. The difficulty of arriving at definite conclusions is chiefly due to the defective and even misleading character of the occupation mortality returns in which marble cutters and polishers are combined with other stone workers, and even quarrymen. All of the available statistics, however, emphasize the lamentable fact that the proportionate mortality from pulmonary tuberculosis is exceedingly high among marble cutters and polishers, and there can be no question as regards an increased liability to the disease in consequence of the almost universal use of pneumatic tools for marble and stone cutting purposes.

No final conclusions, however, can be arrived at until the entire subject of stone workers' mortality has been subjected to a thoroughly critical and qualified analysis with a due regard to the chemical and mechanical properties and especially the degree of fineness of the different varieties of stone dust and their relation to tuberculosis and nontuberculous lung diseases.

SLATE WORKERS.

The slate industry is of practical importance in only two States—Pennsylvania and Vermont. Of the aggregate value of the product sold in 1915, $4,958,000, these States are credited with $4,200,000, or 84.7 per cent of the total. The reduction in output during the last few years is attributed to the increasing use of artificial roofing materials as well as to the larger proportion of new buildings with flat roofs. The industry, with observations on the chemical and microscopical analyses of slates and methods of production, has been reported upon in considerable detail by T. Nelson Dale and others of the United States Geological Survey.[1]

HYGIENE OF THE SLATE INDUSTRY.

The hygienic aspects of the slate industry have been briefly described by Arlidge, with special reference, of course, to English conditions, which, however, do not very materially differ from those common to the centers of slate production in this country. According to Arlidge, "The dust examined microscopically appears made up of irregular but sharply angular particles, often serrated," but he quotes Dr. Roberts to the effect that "It is wonderful how little the quarrymen complain of any irritation or direct inconvenience from inhaling the dust. They soon become accustomed to their condition in life, and the only two discomforts which they generally seem to suffer are lassitude and thirst," and these appear to be due to fatigue rather than to any other cause. In the actual processes of slate sawing and dressing, Arlidge states that, this being done in closed shops, the workmen employed can not escape breathing the copious dust given off. In this country, however, much if not most of the slate splitting is done outdoors so that the dust hazard is materially reduced. Arlidge quotes Roberts in a statement that, taking all the circumstances into consideration, slate workers are subjected to conditions highly calculated to produce respiratory diseases.

MORTALITY OF SLATE-PENCIL MAKERS.

The most thoroughly scientific study of the sanitary aspects of the industry in Germany has been made by Sommerfeld, chiefly, however, with reference to the manufacture of slate pencils and school slates. The investigation emphasizes the unsatisfactory workshop conditions common to the industry and more or less subject to material improvements. When carried on indoors the work is considered decidedly injurious to health, particularly because of the unsatisfactory economic conditions of the laborers. Tuberculosis is of frequent occurrence, but in all probability the underlying causes are social and economic rather than directly attributable to the risk of slate-dust inhalation. Out of 260 deaths from all causes among slate-pencil makers in two typical communities, 167, or 64.2 per cent, were attributed to pulmonary tuberculosis and 25 to other diseases of the respiratory organs. At certain ages the disease attained extraordinary proportions, reaching 80 per cent of the mortality from all causes at 40 to 45. Comparing the proportionate mortality with certain other occupations in the same district, it is shown that among woodworkers 50.6 per cent died of pulmonary tuberculosis, and among all other occupations, excluding slate workers, the proportion was 45.9 per cent. The percentages for all occupations indicate that the general health of the district was exceptionally bad and that the predisposing causes of the high mortality from pulmonary tuberculosis were induced more by social and economic conditions than by the liability to slate-dust inhalation. The average age at death for slate-pencil makers was 45.7 years and for woodworkers 55.2 years. But the former industry, in all probability, employs a larger proportion of young persons. An analysis of a slate workers' sick fund experience, including, however, only 189 employees, shows that nearly one-third had commenced to work at the industry below the age of 14, and some had been at work from the seventh year of life. Under such conditions, irrespective of the dust danger, it would naturally be expected that the liability to pulmonary tuberculosis would be exceptionally high. Upon physical examination it was found that 34 per cent were of an inferior constitution and 34.4 per cent exhibited some degree of lung impairment. The results of this investigation can not be considered conclusive or applicable to the American slate industry, which is carried on under decidedly better social economic conditions. The investigation by Sommerfeld of this particular trade is, however, one of exceptional importance and suggestive of the methods to be followed in corresponding investigations in this country.[1]

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[1] "Slate in the United States," by T. Nelson Dale and others, U. S. Geological Survey, Bulletin No. 586, Washington, 1914.

ENGLISH SANITARY INVESTIGATIONS.

The slate industry was quite carefully inquired into in 1907 by the English Departmental Committee on Industrial Diseases. Quite a number of witnesses with practical experience, both medical and otherwise, were examined, but the evidence obtained was far from conclusive. In the main, however, the experience seemed to prove that continuous and considerable inhalation of slate dust, according to the work followed, was distinctly injurious and a causative factor in the development of pulmonary tuberculosis. The evidence seemed to show in many cases a preceding fibrosis, often of long duration, suggestive of a considerable degree of similarity in the mechanical properties of slate and quartz dust. The opinion seemed to prevail that working in the quarries was distinctly less injurious than working in the mills, where, of course, the dust hazard would be much greater. It was made quite clear, however, that pure slate dust was rarely met with, but that as a rule the dust inhaled included a considerable proportion of minute particles of adherent quartz. An exceptionally interesting and valuable post-mortem report was presented by Dr. Robert Owen, who, quoting from his notes, stated as follows:

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[1] Handbuch der Gewerbe-Krankheiten, by Theodor Sommerfeld, M. D., Berlin, 1898, p. 225 et seq.

Report of the post-mortem R. R., 48 years, slate quarrier, working in a quarry for 25 years. Permission only was given to open and examine the chest. The body was that of a man over 6 feet, very emaciated, and looked 10 years older than his age. Frequent attacks of bronchitis during the last 20 years. Three years before he died he began to lose flesh and was short of breath. Bronchitis, followed by a good deal of expectoration, which was muco purulent; when his complaint was far advanced he was told that he was suffering from tubercular consumption, but when his sputum was examined, which was done repeatedly, no tubercle bacilli were present. Then the thought occurred to us that the patient was suffering from non-tubercular disease of the lung—that is, fibrosis. He became weaker; Bright's disease followed, and he soon died. That is the history of the case. On examination the right lung was adherent to the chest wall. The adhesions were so thick and firm that they had to be cut with a knife. The pleura was adherent. The lung did not collapse when removed from the body. The left lung was not adherent to the chest wall. In the right lung the pleura was very thick. The bronchi of both lungs were greatly thickened and surrounded by dense bands of fibrous tissue. Both lungs were diminished in size; they were hard and dense, almost like cartilage. Both lungs were somewhat of a buff color, but there was no distinct pigment observed. The bronchi contained much mucus and pus. On microscopical examination of the lung it was found to be a real specimen of fibrotic lung tissue. This is partly a report I had from Glasgow, where I sent a tissue to be examined. The walls of the air cells were thickened; also the walls of the minute arteries were in the same condition. The bronchial glands were enlarged (that is my own observation) and of a peculiar color. They were nothing like the glands you find in a coal miner. In this case no tubercular cavities were found; there was no breaking down of the lung. The second case is not so important, as tubercular disease supervened, but the general condition of the lung was the same. I made no microscopical examination in that case.

It would seem from this examination that the conditions observed were quite typical of fibroid phthisis, more or less directly related to slate dust; but in the case of a slate quarryman the physical condition of the lungs would, of course, be less seriously impaired than in the case of a mill worker exposed more continuously and more considerably to the fine dust inhaled. In the mill also the dust particles would be much more minute than in the quarry and the favorable outdoor conditions would be absent.

SOCIAL AND SANITARY CONDITIONS IN THE AMERICAN SLATE INDUSTRY.

In the United States, particularly in the Bangor slate district of Pennsylvania, somewhat similar conditions have been observed. The economic condition of the slate workers in this country is, however, so much superior to that of slate workers abroad that this factor by itself unquestionably operates distinctly in the direction of a lower death rate from pulmonary tuberculosis. The hours of labor are reasonable, the wages are fairly high, the proportion of home owners is relatively large, and the moral conditions, particularly as regards temperance, are distinctly good Slate work is frequently a family trade and is, as a rule, commenced rather early in life. Boys are often employed on school-slate work, which by itself is one of the obviously unhealthy branches of the industry. The specific occupations are quite numerous, but most of the employed are returned as "slaters," millmen, hole men (quarry drillers), and quarrymen. Employments such as slate cutters and slate dressers are more generally covered by the term "slaters" or "millmen." Work at the quarries, which is all by the open or pit method, is considered dangerous, but not distinctly injurious, to health. The dust exposure is apparently not serious, but the ladder-climbing in and out of the quarry involves occasionally a heavy physical strain. Work at the channeling machines is also relatively free from dust, and no evidence is available to show that either quarrymen or those occupied in related occupations suffer above the average from pulmonary tuberculosis. After the slate has been quarried in good-sized blocks it is hoisted out of the pit to the banks where the shanties or huts of the "splitters" or "dressers" are located in large numbers. These are among the principal occupations in connection with slate dressing, and, while there is a reasonable amount of dust exposure, the fact that most of the work is done out of doors reduces the liability to dust inhalation considerably.

In connection with the work of the blocker, who performs the first operation which somewhat resembles the work of paving-stone cutting, the work is all done in the open air, and whatever dust is created by the process is rather heavy and falls readily to the ground before it has a chance to rise. The blocks are first wetted down by a swab or mop, which is essential for good cleavage, and which also tends to reduce the dust menace. The work is not considered seriously to predispose to pulmonary tuberculosis. The men observed in this and related occupations in the slate industry present a favorable, robust, and healthy appearance. From the block maker or bank men the block or slab of slate goes to the splitter, who usually sits on a cushion or wooden seat on the ground, his legs being covered with rugs or an old blanket to guard against injury to the slabs of slate and to protect himself from cold and dampness. This constrained position must in time have some effect upon health, particularly as regards circulatory and digestive disturbances. The dust at this stage of the operation is not very serious, except that on account of the splitter's peculiar position near to the ground it is more readily inhaled. The dust danger, although present in this employment, is not considered sufficient to produce an increased liability to pulmonary tuberculosis. The next operation is that of the dresser, who by means of a cutting machine trims the edge of the slate to the required size. The machine is operated by foot power, and the steady up-and-down movement of the right leg may in time have some health-injurious results, which, however, have not become a matter of official record. The power required to run the machine is quite considerable. Much dust is at times created by this process, according to the character of the slate. As a rule, however, the dust is heavy and falls at once to the ground. Most of the men in this employment have been at work for many years, and they give the personal impression of a healthy, robust, sober type. The very fine dust is not considered excessive, and no evidence is available to prove an abnormal frequency of pulmonary tuberculosis among this class of employees.

OCCUPATIONAL HAZARDS IN SLATE MILLS.

The remaining occupations are generally comprehended under the term "millwork," and it is in these that most of the dust injury occurs. Millmen and others employed in this group of occupations of the slate industry constitute about one-fifth of the whole. The work includes the making of marbleized slate, which involves an additional dust problem. A brief description is difficult, but the existing situation in the Bangor and similar slate districts may be summed up in the statement that the dust menace is fairly well recognized and that no material conflict of opinion prevails concerning the relation of certain mill processes to pulmonary tuberculosis. How far it would be possible to control the dust problem in this branch of the industry has not been ascertained by qualified inquiry. The question was raised in the investigation made by the Departmental Committee on Industrial Diseases and the conclusion arrived at was essentially that effective ventilation would be quite difficult, but that more spraying might be employed to advantage.

Concerning the control of the dust menace in the finishing processes in the manufacture of writing-slates it is stated in the report of the chief inspector of factories and workshops for 1910 that while a considerable amount of dust is given off in this process, a certain amount or proportion of the same can not be exhausted by ventilating devices such as hoods and exhaust fans, on account of the weight of the dust, which by gravity falls to the ground. Mr. J. L. Edwards, of Wrexham, suggested a perforated worktable with a water trough underneath, which in actual practice was found to give good results.

It is regrettable that the available information regarding this important branch of the mineral industry should be so limited and, partly at least, inconclusive. The decline in production during the last few years no doubt accounts, in a measure, for this neglect, which is so much the more regrettable since, aside from humanitarian and economic considerations, the scientific aspects of the slate-dust problem are of special importance. There are as yet no trustworthy official vital statistics for this country, although an analysis of the mortality in slate-producing centers would unquestionably yield useful results. In the subsequent discussion of the mineral industries slate workers are again briefly referred to, chiefly with reference to slate quarrying. In a general way the data sustain the conclusion that the inhalation of slate dust is relatively less serious in its effects on the lungs than the inhalation of more irritating forms of mineral and metallic dust.

In the industrial insurance experience of the Prudential Co. during the period 1907 to 1914 there were 93 deaths of slaters, of which 12, or 12.9 per cent, were from pulmonary tuberculosis. In addition, there were 10 deaths from nontuberculous respiratory diseases, equivalent to 10.8 per cent of the mortality from all causes. There were also 7 deaths of slate makers, with 2 deaths from pulmonary tuberculosis. The statistical evidence, although entirely too limited for final conclusions, apparently sustains the point of view that exposure to slate dust is less serious in its effects than continued and considerable exposure to more irritating forms of mineral and metallic dust.

LIME WORKERS.

The lime and cement industries are so closely related to each other that for practical purposes it has been found difficult to give separate consideration to the mortality returns for each group of these employments, which have therefore been combined to provide a more substantial statistical basis in support of the conclusions advanced. Cement and lime, of course, have different properties, dependent upon their chemical composition and the methods of manufacture, and are generally classified either according to the chemical reaction involved in setting or according to the conditions under which they will harden. Chemically pure lime is the oxide of calcium, which, as shown in the description of the cement industry, constitutes the major portion of the cement product. Lime is a strong caustic alkali which unites readily with many substances and is readily soluble in water at ordinary temperature. On this account it is claimed that the inhalation of lime dust is noninjurious, and some authorities go so far as to ascribe beneficial results to lime-dust exposure as a precautionary measure against a risk of tuberculosis.[1] There are, of course, numerous varieties of limestone which may vary in their effects and unquestionably do so where there is a considerable degree of intermixture with shell, chalky, cherty, or other substances. The general processes of manufacture, without reference, however, to sanitary conditions or dust exposure, have been described in a report of the Missouri Bureau of Geology and Mines on lime and cement resources (Jefferson City, Mo., 1907) and in part 2 of the Mineral Resources of the United States for the calendar year 1913, by Burchard and Emley, on "The sources, manufacture, and use of lime." The annual reports of the United States Geological Survey emphasize the magnitude of the lime industry, but no satisfactory statistics are available concerning the health of this class of employees with special reference to tuberculosis other than the data elsewhere included in the discussion. Hayhurst in his report on health hazards in Ohio reports upon conditions observed in seven establishments employing, however, only 188 persons. A brief reference is made to dust exposure in the drawing or unloading of the kilns in connection with which no protective devices were employed. As regards grinding and packing, it is said that this is done in all plants but is practically a side practice or process of lime manufacture. It is explained that the lumps of lime after cooling on the floor space are taken to the mill and ground to powder and then sacked by machinery. The health hazard is referred to as "very bad." The air is dense on account of the dust in some places, and in only one was there an efficient suction system, in connection with which it is pointed out "the saving of lime collected paid a very good interest on the money invested in the blower system." Skin irritation, especially in summer, is referred to as frequent, and eye inflammations were complained of, but there is no mention of a specific liability to pulmonary tuberculosis. The idea seemed to prevail that the inhalation of lime dust was beneficial and in some communities medical evidence to this effect was quoted. Some of the men observed, however, were decidedly pale and a few were short of breath, an impairment acquired since entering the plant.

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[1] "The Influence of Calcium," Appendix II, The Cancer Problem, by C. E. Green, F. R. S. E., Edinburgh, 1917.

LIME DUST AND PULMONARY TUBERCULOSIS.

The relation of lime-dust inhalation and pulmonary tuberculosis was investigated by Reckzeh, who, according to a brief statement in the Medical Record for December 5, 1903, concluded that—

> The statistics in lime-producing districts show that pulmonary tuberculosis is rare, and that sometimes when present its course is favorably affected. Various authors ascribe this beneficial effect to different features attending the occupation of lime burning. Such are, an effect of the inhaled lime dust in facilitating calcification of the suppurating foci, the dryness of the inhaled air, and the deeper respiration it makes necessary, the warmth of the inspired air which contains no tubercle bacilli, and the more active metabolism it causes. In order to determine the effect of the lime dust suspended in the air the author caused eight tuberculous patients to inhale air charged

with the dust by striking suspended bags filled with powdered lime. At first the inhalations were carried on for five minutes daily, but the time and frequency were gradually increased. The results were without encouragement, no improvement in the pulmonary condition was noted, while there were marked undesirable secondary effects, such as headache, loss of appetite, and nausea.

RELATIVE INFREQUENCY OF RESPIRATORY DISEASES.

Selkirk subsequently investigated the same problem by personal inquiry among lime workers with special reference to the prevailing opinion that as a class they were exceptionally free from bronchitis and pulmonary tuberculosis. According to the Journal of the American Medical Association, for December 12, 1908—

> He was unable to find an instance of phthisis among them, nor could he learn on inquiry of any worker in limekilns having died from tuberculosis. He asks whether those who inhale and swallow much lime are abnormally free from tuberculosis of the lungs. He discusses what is known of the therapeutics of calcium salts, and says it appears that the continued absorption of calcium from the lungs and intestines might maintain an abnormally high percentage of it in the blood. He suggests that the workingman predisposed to tuberculosis might turn his attention to lime and cement working as an occupation, and even hints at the organization of lime works as a curative tuberculosis colony. A rapid increase of weight is commonly observed in new workers at the Warren Cement Works, at Hartlepool.

GENERAL CONCLUSIONS.

The same authority is also quoted, but in another statement, that he found the health of workers in limekilns above the average, and that there seemed to be far less than the normal amount of pulmonary tuberculosis and bronchitis. He therefore concluded that—

> It is believed that the lime inhaled is dissolved by the carbonic acid in the lungs and absorbed. Calcium in the intestinal canal prevents fermentation. Lime-dust particles may, however, be deposited in the lungs. It may be that continual absorption of calcium from the lungs and intestine may maintain an abnormally high percentage of it in the blood. The author asks, Does this occur in the lime worker, and is it preventive of tuberculosis in him? Or is his freedom due to the external lime dust being unfavorable to the life and growth of the bacillus outside of the body? It seems curious to suggest an atmosphere of dust for the treatment of tuberculosis; it would have been as curious some generations ago to have suggested fresh air. At the least, have we not in this lime and cement working an occupation which we may recommend to the workingman predisposed to tuberculosis or already in the early stages of it? Or could the neighborhood of a limekiln be organized as a curative tuberculosis colony?

These observations arrived at by conservative medical investigators seem to sustain the generally favorable conclusions concerning the relative noninjuriousness of lime dust with special reference to pulmonary tuberculosis. As a technical problem the lime industry offers exceptional opportunities for the ascertainment of urgently required information concerning the differential effects of mineral dusts in their relation to health and longevity and possibly even concerning the therapeutic value of lime dust as intimated by the rather limited investigations of Reckzeh and Selkirk.

An excellent descriptive account of "Lime: Its properties and uses" has been published as a circular of the United States Bureau of Standards of the Department of Commerce and Labor (Washington, 1911). This account precisely emphasizes all the essential preliminary scientific considerations necessary for a thorough understanding of the underlying conditions which concern the health of workers in occupations, trades, or industries more or less injurious to health and life. The account includes a description of the method of lime manufacture, definition, and classification, followed by a description of general properties and an extended account of the uses of lime and the various kinds of limestone, lime, and hydrated lime in the chemical industries, including natural cement, sand-lime brick, glass, bleaching powder, fertilizer, etc. The classification of limestones according to their physical properties, as to whether hard or soft, porous or dense, coarsely crystalline or fine grained, implies probably widely differential results in health-injurious consequences, proportionate, of course, to the continuity and amount of dust exposure. Limestone, when metamorphosed—that is, when recrystallized after deposition through the agency of heat—is known as "marble," which by inference suggests that marble dust in all probability is not as serious in its consequences as granite dust and possibly sandstone dust, both of which contain a larger proportion of pure silica.

Some exceptionally interesting observations on dust exposure in the working of oolitic limestone on the Isle of Portland, England, contributed by Dr. Howard to the annual report of the chief inspector of factories and workshops (1913), include statistical observations for the 13-year period ending with 1912. The mortality from phthisis per 1,000 living was, among general laborers, 1.9; among stone quarriers, 1.5; among stone masons, 1.4; and among all other males, 1.1. Corresponding statistics are those of Barwise for Derbyshire, elsewhere referred to, according to which the death rate of persons employed in gritstone quarries was 13.7, against 1.2 for limestone workers. A brief reference is made in the discussion to an address by Dr. Collis on the "Effects of dust in producing diseases of the lungs," read at the Seventeenth International Congress of Medicine held in London in August, 1913, in which after the effects of dust on those employed in various industries had been cited, the following conclusions were advanced:

1. Inhalation of all forms of dust is accompanied by diminished power of chest expansion.
2. Diminished power of chest expansion so produced is accompanied by high blood pressure.
3. Animal dusts, apart from the presence in them of pathogenic microorganisms, when inhaled, produce less effects than do vegetable and mineral dusts.
4. Vegetable dusts, when inhaled, tend to produce a type of chest affection best described as asthmatic.
5. Of mineral dusts, those composed of calcium salts are least injurious.
6. Inhalation of mineral dusts which do not contain free silica tends to produce irritation of the upper air passages and respiratory diseases other than phthisis.
7. Inhalation of mineral dusts which contain free silica is associated with an excess of phthisis, an excess which bears a direct relation to the amount of free silica present.
8. In general, dusts appear to be more injurious as their chemical composition differs from that of the human body or from the elements of which the body is normally composed.

Of the foregoing observations the conclusion that of mineral dusts those composed of calcium salts are least injurious is, of course, of special significance, in view of the preceding discussion regarding the health of lime workers, which it is regrettable could not be amplified by other American or foreign vital statistics of a sufficiently trustworthy character.

PLASTERERS.

The building trades are all more or less exposed to the inhalation of mineral dust, the injurious effects of which are probably most severe in the case of plasterers, masons, and allied occupations. This group of occupations is not clearly defined, since many plasterers are also masons, or bricklayers, while others are whitewashers or paper hangers. The English vital statistics combine plasterers, whitewashers, and paper hangers.

EARLY OBSERVATIONS ON THE HEALTH OF PLASTERERS.

The health conditions in this trade were commented upon by Ramazzini, who, in the quaint language of the day, states that "Lime and plaster are likewise offensive to those who burn them or handle them, or sell them," and he continues: "I have frequently observed that those who boil, prepare, grind, sift, or sell it, do usually labor under a difficulty of breathing." As a safeguard, Ramazzini points out that: "Though such workmen have a cover for their mouth, they can not avoid receiving the flying particles at the mouth and nose, upon which these particles enter the passages of respiration and mix with the lymph, rise up in hard, chalky concretions, or by daubing the winding passages of the lungs intercept freedom of breath. I found that such as continued in this business did die asthmatic and cachetik." He refers also to a still earlier author, Morton, who connected the inhalation of the dust with pulmonary tuberculosis. He concludes his observations with the statement that: "Care must be taken to observe the caution laid down above, with intent to guard the mouth as much as possible from receiving the offensive particles." All this was written more than 200 years ago!

Thackrah, writing in 1832, took a more favorable view of the employment, holding that bricklayers and their laborers, while particularly exposed to lime dust, suffered from diseases of the eye and cutaneous eruptions, but not from internal disease, and he quotes an adage common to the workmen in the trade of the period, that "bricklayers and plasterers' laborers, like asses, never die." Regarding plasterers and whitewashers, who are also exposed to lime dust, he states: "They suffer from no sensible injury," and that "they are more pallid and less robust than bricklayers." Thackrah, however, did not support his observations with trustworthy data.

ENGLISH MORTALITY DATA.

The most recent English mortality statistics of plasterers and paper hangers are for the three years ending with 1902, referred to in the Supplement to the Sixty-fifth Annual Report of the Registrar-General, in part as follows:

> Between the ages of 35 and 65 years the death rate in this industry exceeds the standard for occupied and retired males, while at ages outside of these limits the rates are below it. In the main working period of life the comparative mortality figure is 1,018, or within 1 per cent of the standard. The mortality from alcoholism and liver disease, from phthisis, from respiratory diseases, and from cancer slightly exceeds the standard, and except that these workers appear to suffer but little from influenza, the figures for other diseases agree closely with the average.

The English occupation mortality statistics for plasterers are somewhat impaired in value by the fact that paper hangers and whitewashers are combined with this occupation, but the statistics may safely be accepted as indicating with approximate accuracy a higher disease liability of men in this employment to pulmonary tuberculosis and respiratory diseases. In Table 84 the mortality from all causes among men in this group is compared with that of occupied males generally, and the result is rather suggestive of conditions in this trade more or less unfavorable to life and health. The excess in the general mortality occurs at ages 35 to 64, when the death rate of plasterers from all causes exceeds the mortality of occupied males generally by from 1.30 to 1.52 per 1,000. The mortality of the group is, however, below the average at ages under 35 and at 65 years or over.

TABLE 84.—MORTALITY FROM ALL CAUSES AMONG PLASTERERS, PAPER HANGERS, AND WHITEWASHERS, COMPARED WITH THAT OF ALL OCCUPIED MALES, IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[Source: Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 for all occupied males.	Death rate for plasterers, paper hangers, and whitewashers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Per cent of rate for all occupied males.
15 to 19 years	2.44	1.52	− 0.92	62
20 to 24 years	4.41	3.44	− .97	78
25 to 34 years	6.01	4.07	− 1.94	68
35 to 44 years	10.22	11.52	+ 1.30	113
45 to 54 years	17.73	19.18	+ 1.45	108
55 to 64 years	31.01	32.53	+ 1.52	105
65 years and over	88.39	72.18	−16.21	82

The preceding table requires no further comment, except that it confirms the view that the health-injurious effects of this employment are not so pronounced as in many other dusty trades, particularly such occupations as stonecutting, pottery manufacture, and glass blowing. In Table 85 the mortality of plasterers, paper hangers, and whitewashers from pulmonary tuberculosis is compared with the normal mortality of occupied males from this disease by divisional periods of life.

TABLE 85.—MORTALITY FROM PULMONARY TUBERCULOSIS AMONG PLASTERERS, PAPER HANGERS, AND WHITEWASHERS, COMPARED WITH THAT OF ALL OCCUPIED MALES, IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[Source: Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 for all occupied males.	Death rate for plasterers, paper hangers, and whitewashers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Per cent of rate for all occupied males.
15 to 19 years	0.54	0.41	−0.13	76
20 to 24 years	1.55	1.06	− .49	68
25 to 34 years	2.03	1.22	− .81	60
35 to 44 years	2.74	3.98	+1.24	145
45 to 54 years	3.04	3.62	+ .58	119
55 to 64 years	2.16	4.01	+1.85	186
65 years and over	1.11	1.53	+ .42	138

RECENT AMERICAN INVESTIGATIONS.

The most recent investigation into the existing health conditions is by Balentine C. Baker, M. D., published in the Journal of the American Medical Association for May 6, 1916. The results of this investigation, made in connection with the Cornell University Medical College, are, in part, stated as follows:

> In the work of the plasterer there is exposure to dust, cold, and dampness. The source of the dust is from the plaster, which is usually composed of lime, sand, and hair moistened. Anyone at all familiar with the work of a plasterer knows what dust there is when the dried plaster is crumbled loose by walking, moving of objects, and sweeping. The drafts of air through the open doors and windows fill the atmosphere with dust, and this the worker has to breathe. There is some controversy among investigators as to the danger of lime to workers. Selkirk was unable to find any instance of phthisis among them, nor could he learn of any worker in lime-kilns having died of tuberculosis.

The special investigation included 36 cases of plasterers under treatment as patients at the hospital referred to, and of this number 17, or 47.2 per cent, were over 40 years of age. It is said in conclusion that—

> The respiratory tract of the plasterers is chiefly affected as in the preceding trades, there being 13 patients in this class. Seven patients had chronic and 6 acute respiratory disease. Three patients had pulmonary tuberculosis, 3 chronic bronchitis, 2 emphysema, 2 acute bronchitis, 3 dry pleurisy, and 1 acute pharyngitis.
>
> These observations are suggestive of nontuberculous respiratory rather than of tuberculous affections, but the number of cases under observation is too limited for a conclusive generalization.

METHODS OF PLASTER OF PARIS MANUFACTURE.

A clear distinction, of course, must be drawn for practical purposes between the manufacture of plaster of Paris and the occupation of plasterer. The former includes the crushing of raw material, employment at rotary driers, and the so-called "dust room." with supplementary methods of bowl crushing to a condition of minute fineness on buhrstones; and finally calcining in kettles with the terminal processes of handling through hoppers, bins, and conveyers. No conclusive investigations have been made with regard to the specific dust exposure in these processes and their relation to health, but W. Gilman Thompson writes of the occupation of masons and plasterers at some length, including concrete mixers, who, of course, are exposed to fundamentally different conditions. He points out that men in this group of employments inhale much dust of tile, brick, plaster of Paris, gypsum, and cement, and that they are subject from these combined conditions "to catarrhs of the respiratory passages, and such diseases as asthma, bronchitis, rhinitis, and atelectasis are frequently met with among them." There would seem to be much similarity in the dust exposure of these occupations to that observed in the case of lime and cement workers. The exposure to dust of this character is most serious in connection with house-wrecking operations, where heavy clouds of masonry and plaster dust are generated and inhaled in connection with particularly laborious work. Thompson suggests, therefore, that in some cases, as in the tearing down of old plaster in confined spaces, in tunnels, etc., where sprinkling can not be resorted to, respirators may be used to advantage.[1]

MORTALITY OF PLASTERERS—UNITED STATES REGISTRATION AREA.

The mortality of plasterers has been reported upon for the years 1908 and 1909 by the Division of Vital Statistics of the United States Census Bureau, but for the year 1908 the group includes whitewashers, who, of course, are engaged in a closely allied employment. According to the census report, out of 977 deaths of plasterers from all causes, 163, or 16.7 per cent, were from pulmonary tuberculosis. The details of the mortality by divisional periods of life are shown in Table 86.

TABLE 86.—PROPORTIONATE MORTALITY OF PLASTERERS FROM PULMONARY TUBERCULOSIS, UNITED STATES REGISTRATION AREA, 1908 AND 1909, BY AGE GROUPS.

Age at death.	Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent of deaths from all causes.
15 to 24 years	48	12	25.0
25 to 34 years	108	34	31.5
35 to 44 years	177	61	34.5
45 to 54 years	189	31	16.4
55 to 64 years	205	16	7.8
65 years and over	249	9	3.6
Age unknown	1		
Total, 15 years and over	977	163	16.7

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[1] The dust exposure in the making of plaster casts must be quite considerable on account of the close contact with the material during every operation from the making of the molds to the finished product. Exposure is probably most serious in the scraping department, which is shown by illustration in a descriptive account on "The making of casts in gelatin molds," by W. Frank McClure, published in the Scientific American for June 20, 1908. The wearing of face protectors is necessary in this department. The object of the scraping is the removal of the mold seam and other unavoidable defects. Most of the dust exposure, however, results from the scattered material which dries and is subsequently blown about. How far this employment is as a matter of fact really health-injurious, and a predisposing cause to respiratory diseases, whether pulmonary or otherwise, has not been ascertained.

TABLE 87.—PROPORTIONATE MORTALITY OF PLASTERERS FROM NONTUBERCULOUS RESPIRATORY DISEASES, UNITED STATES REGISTRATION AREA, 1908 AND 1909.

Cause of death.	Deaths from nontuberculous respiratory diseases.	
	Number.	Per cent of deaths from all causes.
Asthma	3	0.3
Bronchitis	11	1.1
Pneumonia	79	8.1
Other nontuberculous respiratory diseases	11	1.1
Total	104	10.6

The proportion of deaths from pulmonary tuberculosis in this occupation is fairly high, but not distinctly excessive, excepting at ages 35 to 44, when the proportion is 34.5 per cent for plasterers, against 24 per cent for all occupied males, according to data derived from the same official sources. Aside from the mortality from pulmonary tuberculosis, the mortality from nontuberculous respiratory diseases was also about normal, having been 10.6 per cent for plasterers, against 10 per cent for all occupations, the slightly higher proportionate mortality from nontuberculous respiratory diseases being chiefly attributable to bronchitis; but the numbers under consideration are hardly sufficient for entirely definite conclusions.

MORTALITY OF PLASTERERS—INDUSTRIAL INSURANCE EXPERIENCE.

In this connection the statistics of the Prudential Insurance Co. are of additional interest and value, in that they include 1,371 deaths from all causes, of which 300, or 21.9 per cent, were from pulmonary tuberculosis.

TABLE 88.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG PLASTERERS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, COMPARED WITH THAT OF ALL MALES IN UNITED STATES REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of plasterers, 1897 to 1914, from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Plasterers.	Males in registration area, 1900 to 1913.
15 to 24 years	58	20	34.5	27.0
25 to 34 years	163	71	43.6	30.5
35 to 44 years	225	91	40.4	23.4
45 to 54 years	281	66	23.5	14.7
55 to 64 years	330	39	11.8	7.9
65 years and over	314	13	4.1	2.6
Total, 15 years and over	1,371	300	21.9	13.9

According to Table 88 the proportionate mortality from pulmonary tuberculosis is excessive among plasterers at every divisional period of life, but particularly so at ages 25 to 34, when out of 163 deaths from all causes, 71, or 43.6 per cent are from pulmonary tuberculosis, against 30.5 per cent in the male mortality of the registration area. How far this excess in the mortality from pulmonary tuberculosis is the direct result of dust inhalation or due to contributory social and economic causes can not be stated at the present time. Nor is it possible accurately to differentiate plasterers from men employed in the manufacture of plaster of Paris and related occupations, but it may be said in conclusion that such investigations as have been made of existing conditions at plaster works prove that there is abundant room for material improvement, and that in most of the plants only the crudest and most unsatisfactory appliances are employed for the prevention of dust and its inhalation by the men employed.

In this connection a brief reference may be made to an exceptionally valuable tabulation of industries with exposure to inorganic dusts in relation to the mortality from pulmonary tuberculosis and the presence of free silica in the dust, in the annual report of the chief inspector of factories and workshops of Great Britain, for 1912 (p. 216). As regards plaster of Paris, it is said that the composition of the dust is chiefly that of calcium sulphate and that free silica is not present; also that the mortality from pulmonary tuberculosis is not above the normal. A similar reference is made to cement, as regards the composition of which it is said that the dust consists of silicates of magnesium, calcium, and aluminum; that the percentage of free silica is less than 1 per cent (as compared, for illustration, with 30 per cent in granite dust and 75 per cent in quartz dust of the tin mines of Cornwall); and, finally, that the mortality from pulmonary tuberculosis is "not above normal." Attention is directed to the fact that the connection between silica dust and phthisis is now well established, and that it has led to the adoption of preventive measures to suppress this dust when generated in the process of sand-blasting glass for engraving purposes and in the production of finely powdered flint and quartz. Free silica, however, as brought out in this investigation, is not present in the dust of plaster of Paris which on that account chiefly is relatively noninjurious as regards predisposition to pulmonary tuberculosis. The most recent observations, in Kober and Hanson's Diseases of Occupation and Vocational Hygiene, regarding plasterers, are regrettably inadequate and inconclusive.

CEMENT WORKERS.

The health-injurious conditions of cement-making processes are quite well understood, being not only the dust, but also the noxious vapors which arise through the process of burning. The vapors are probably more a matter of discomfort than injurious, but the subject attracted sufficient attention to suggest an investigation by the Royal Commission on Noxious Vapors in 1878.[1] As a result of the vapors and the dust generated during the processes, cement works, as a rule, are now located outside of large cities.

GAS, FUME, AND DUST EXPOSURE IN CEMENT-MAKING PROCESSES.

The health conditions in American cement works have never been fully investigated, but it appears to be the consensus of opinion that the effects are not as serious as assumed upon the facts of a casual inspection.[2] Fatal accidents have occurred as the result of asphyxiation by carbon-monoxide gas, but such cases are very rare. Cases of gassing, so called, which do not terminate fatally, are said to be comparatively common. Arlidge considered the employment of cement making at some length, pointing out that the workmen are exposed to dust in an intense form, but experience would seem to prove that the effect on health is not so injurious as expected. He states that the raw materials of cement are clay with flint and lime, and he briefly describes the process of manufacture as follows:

> After the materials have been well mixed and ground together in a sort of mortar mill to the consistency of liquid mud, the next business is to drive off the water by heat, and then to subject the dried substance in tins to a still higher temperature. Later all the cement is withdrawn and then ground between rollers to the requisite fineness. The primary mixing and grinding, being done with a free supply of water, exhibits no insanitary conditions. In working the kilns the workmen suffer from great heat and dust, but the most continuous dusty work is in the mill, the air of which is clouded with cement. Inquiry among the workmen elicited the fact that after a while they become short of breath and suffer cough, though not in a high degree, and that on arising in the morning they had to clear their chests by expectorating viscid mucus containing cement dust.

QUANTITATIVE EXTENT OF ATMOSPHERIC POLLUTION.

The amount of dust generated in cement-making processes is enormous. The workmen take practically no precaution to avoid this dust, and considerable quantities are of necessity inhaled. It is very rare to find employees who use a respirator or even a piece of ordinary cloth to provide some protection against the health-injurious conditions which surround them. The worst conditions are probably in the sacking or packing department, where such precautions are occasionally adopted. Every department, however, is filled with dust, and the avoidance of its inhalation by the majority of employees is under present methods practically impossible. The disease problem is complicated by a high degree of temperature in some of the departments, in particular at the kilns. While many descriptive accounts of the industry have been published, the hygiene of the occupation has been generally ignored. Tracy refers to it very briefly, holding that "the workmen who make Portland cement are greatly troubled by the dust caused by shoveling the mass into sacks after it has been burned and ground. They have a persistent cough, and expectorate little lumps of cement. They find it impossible to continue this part of their labor day after day, and are obliged to take intervals of rest."

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[1] Report of the Royal Commission on Noxious Vapours, London, 1878. Minutes of Evidence taken before the Royal Commission on Noxious Vapours, London, 1878.

[2] This conclusion is modified by the investigations of Dr. Tucker, of Riverside, Cal. (see pp. 233 to 237). The investigations of Dr. Tucker are a notable contribution to the subject of cement dust in its relation to health, but they can not be considered entirely conclusive, in that the statistical data—either that secured by him from local sources or that derived from insurance experience—are not sufficiently representative of the American cement industry with a due regard to local variations in conditions injurious to health.

PROCESSES OF MANUFACTURE.

Parry, in his Risks and Dangers of Various Occupations, refers to cement workers as follows:

> Those engaged in the manufacture and use of Portland cement are very liable to get the dust into their lungs. Portland cement is made from some substance containing carbonate of lime, such as white chalk, existing in such immense quantities in this country, and some material containing silica and alumina, such as a selected clay or alluvial mud. These are ground together with water to a muddy consistency, which is then dried by heating in chambers. This being a wet process, no dust is raised, but during the next stage, the digging out of the cement, a great deal of dust is created. The material raised is then calcinated, ground between rollers, and finally packed in bags. In the last two operations, the grinding and packing, much dust is also scattered. The particles are of a sharp, irritating character, and therefore dangerous.

In Oliver's Dangerous Trades the manufacture of cement from a hygienic point of view is briefly discussed and illustrated by a microphotograph of cement dust by Migerka. Oliver's description is as follows:

> Under the microscope are seen a few sharp-edged little plates and amorphous masses like small clumps. The particles are not of themselves so dangerous as might at first sight appear. Although cement workers suffer from pulmonary disease, they do not do so to the great extent that might be expected. Probably the harmful effects are largely due to the hygroscopic character of the particles and their alkaline reaction.

MEDICAL OBSERVATIONS ON CEMENT DUST.

The cement industry has also been reported upon by Hayhurst with special reference to conditions in Ohio, including, however, only two plants, employing a total of 98 men. It is stated that the work was found to be very dusty and dirty and that the quarters in one place were seldom cleaned. It is, of course, a foregone conclusion that it is practically impossible to keep a cement plant in a thoroughly clean condition while in active operation, since the product itself is the dust which permeates practically every part and portion of the plant. According to Hayhurst, the dust is composed of "cement, lime, silica, and powdered coal," and thus far practically no method has been evolved for the control of the dust menace. Heat was found to be intense for some of the workers and there was practically no protection adopted against it. This, of course, applies to the calcining furnaces, which do not essentially differ from converting furnaces generally. The medical observations are to the effect that there was great opportunity for contracting communicable diseases because of promiscuous spitting, absence of cuspidors, and the dust flying about. It was also noted that the cement dust tended to cake in the nose and that same was more or less contaminated by the dust of pulverized coal, which of course would probably not be a condition common to cement plants generally. The observations can not be considered conclusive in view of the very limited range of the inquiry.

On account of the truly enormous extent of the development of the cement industry during recent years, general conclusions should be accepted with extreme caution. Descriptive accounts of plant conditions vary widely, and for a thorough understanding of the conditions inimical to health a much more extended investigation is required than has thus far been made In the special account of the cement industry of the State of Kansas, prepared in connection with the St. Louis Exposition, 1904, occurs a concise statement of the Iola Portland cement plant, which sets forth the general processes and conditions with admirable brevity, as follows:

> The materials used in the manufacture of the cement are a very pure limestone nearly free from magnesia, a clay with about 75 per cent of alumina, and silica. One thousand tons of rock are used every 24 hours. These substances are mixed in the proper proportion and then ground in a large rock crusher, which takes blocks as large as a man's hand and has a capacity of 15 tons per hour. The gravel from these crushers then passes into a dryer heated by natural gas, where it loses 6 per cent of water, or 60 tons a day passing off as steam. Next the gravel is ground in 21 Griffin mills, which grind 2 tons an hour, or 48 tons per day, to a fine flour which will pass through a 100-mesh sieve of 10,000 holes to the square inch. This flour is then conveyed to the 15 agitators, large cylinders holding 90 cubic yards each, and it is thoroughly mixed in water by revolving propellers.
>
> When the material is thoroughly mixed to the satisfaction of the chemist it is carried into 21 rotary kilns. These are cylinders lined

with fire brick and are 6 feet in diameter. They are in constant rotation and inclined downward slightly toward the gas-heated end, where the temperature reaches over 3,000° Fahrenheit. Each kiln has a capacity of 160 barrels in 24 hours. The mixed flour materials pass out of the kiln in the form of a hard clinker, which is carried by elevators over into the cooling room. When cooled, the clinker is placed in a second set of Griffin mills, 21 in number. Each one of these grinds 9 barrels (or 3,420 pounds) in an hour to a fine flour. The finished cement now passes over into the storage room, where it is run into barrels or sacks.

COMPARATIVE DUST HAZARDS IN THE DRY AND WET PROCESSES.

The manufacturing processes have also been described by Mr. John Calder, chief inspector of special risks for the Canadian Fire Underwriters' Association, who points out at the outset that there are two methods, generally known as the dry and the wet system, which naturally involve processes and conditions quite varying in their effects on health and longevity. The dust danger in the dry process is, of course, most serious, particularly in connection with the crushing, mixing, and grinding briefly described as follows:

The limestone being received at the mill passes through a jaw crusher. It then goes through rolls for a further reduction and is elevated to storage bins. From the storage bins the rock goes to the rock driers; these usually consist of metal cylinders from 40 to 60 feet long and 5 to 6 feet in diameter, with flanges inside and placed horizontally with a slight inclination and revolving on roller bearings. These driers are usually heated by a coal furnace or by waste gases from the rotary kilns. The shale or clay is treated in a similar manner, the whole going to the raw-stock bins. From these the two materials are drawn and mixed, usually by automatic mechanical mixers taking in the proper proportions required from an analysis of the materials. The further reduction of the mixture is done by two grindings, the first usually in the Ball Griffen or "Kominuter" mills and the latter in the tube mill. The stock is then conveyed to the raw-stock bins ready for burning.

W. Gilman Thompson has described the dust exposure in cement manufacture, with special reference to American conditions, observing in part that—

In the crushing and drying rooms where the limestone is first treated, and in barreling or bagging, the workmen are exposed to risk of bronchial and pulmonary irritation as well as to irritation of the skin and conjunctivae. In the better class of mills the crushing and grinding machinery is inclosed and connected with aspirating ducts or hoods through which the dust is drawn to settling rooms where it is filtered or precipitated with water. The packing in sacks for transportation is sometimes also done by machinery. The workmen frequently further protect themselves by binding thin cloths over the nose and mouth or by wearing respirators. They often complete the filling of the sacks by adding a few handfuls of cement to make up the full weight, thereby scattering much dust and irritating the hands. Cleaning out the clinkers from the ovens in which the raw material has been roasted subjects the workmen to dry heat as well as coarse dust.

Regardless of even the most satisfactory precautions a considerable amount of dust exposure in cement plants is practically unavoidable. In plants in which insufficient attention is paid to dust prevention the quantity of dust exposure is enormous. As observed by W. Gilman Thompson in this connection:

> Upon the whole, in proportion to the quantity of dust inhaled, cement dust, like coal dust, produces less damage to the respiratory system than might be supposed—less than the harder, sharper flint or glass dust, although chronic bronchitis, asthma, and pneumoconiosis may result from it. It causes considerable itching in the nose, to relieve which the workmen put their dusty fingers into the nose and scratch the septum. This only increases the trouble, and in some cases ulceration with perforation of the septum occurs, as in chromic-acid poisoning. Workmen with sensitive skins sometimes scratch the dusty skin so that ulcers form which are so slow in healing that they may be compelled to change their work. The cement dust mixes with the perspiration of the skin and gives rise to a general pruritus which the workmen call "cement itch."

SPECIFIC OCCUPATIONAL DISEASES.

Cement makers' itch is a new disease, apparently neither parasitic nor contagious, but produced by the chemical or mechanical action of the cement upon the skin. According to a brief discussion in the Medical Times (October, 1909)—

> Some physicians have attributed the corrosive action to calcium carbonate and to sulphuric acid. Fresh cement, however, does not contain calcium carbonate; and it is questioned whether slacked lime or even partly slacked lime will produce this effect, for masons working with lime mortar are seldom if ever attacked with cement makers' itch. The quantity of sulphuric acid in cement is very small. Possibly the effect may be explained by mechanical friction between the skin and very fine but hard particles of cement. Briquette makers, observes Scientific American, are subject to a similar but less serious annoyance. Cement makers' itch and ordinary itch have one sympton in common—intense itching, especially at night. The itching appears to be increased by the heat of the bed, and is also more annoying in summer than in winter. Scratching may produce infected wounds and swelling. Cement makers' itch is an occupational disease; true itch is seldom such. The latter can be cured comparatively easy; but not so cement makers' itch, which is likely to be followed by eczema and other complications. The managers of cement works should always require their workmen to wear cotton gloves and garments tightly fastened at the neck and at the wrists. Cement workers on arches or ceilings should wear masks. Both gloves and masks should frequently be washed.

The reference is of some importance in connection with the still debatable question as to whether cement dust is or is not, at least in rare industrial cases, really seriously injurious to health.

EFFORTS AT RESTRICTIVE LEGISLATION.

Under date of January 14, 1913, a bill was introduced into the senate of the State of California providing for the protection of the health of persons employed in the manufacture, packing, or handling of Portland cement, as follows:

The people of the State of California do enact:

Section 1. In any factory or other place in the State, where Portland cement is manufactured, packed, or handled provision shall be made for preventing the escape of cement dust into the atmosphere of any room or compartment where people are employed.

Sec. 2. The packing of Portland cement shall be carried on in compartments which shall be separated by dust-proof walls, floors, and partitions from all other parts of the factory or establishment where people are employed; and all conveyors and elevators used for the conveyance of Portland cement shall be inclosed in metal or some other dust-proof material.

Sec. 3. All Portland cement manufactured in the State, or imported from any other State or foreign country shall be packed in dust-proof containers, and the commissioner of the bureau of labor statistics shall have the power to issue orders to prevent the loading or unloading of any Portland cement in or for any vessel in any port in the State of California or in or for any freight cars, or any railroad or railway in the State of California if such Portland cement is not packed in a dust-proof container; and any person, firm, or corporation who shall disobey such order shall be guilty of a misdemeanor.

Sec. 4. All contracts entered into by this State or any political subdivision thereof, for the purchase of Portland cement or other like commodity or for the construction of public work which requires the use of Portland cement, shall contain a proviso that all cement to be furnished in the construction of such public work shall be packed in dust-proof containers.

Sec. 5. Any person, firm, or corporation who shall violate or fail to comply with the provisions of this act shall be guilty of a misdemeanor and shall, upon conviction thereof, be punished by a fine of not less than $50 or more than $200, or by imprisonment for not more than 60 days, or by both such fine and imprisonment.

Sec. 6. The commissioner of the bureau of labor statistics shall enforce the provisions of this act.

EXPERIMENTAL MEDICAL RESEARCH.

The bill has been included in its entirety as an illustration of contemplated legislation intended to correct an evil of a more or less debatable degree of seriousness by means practically equivalent to the destruction of the industry concerned. The contemplated bill in California led to perhaps the most thorough investigation of the health conditions in a dangerous industry ever made in the United States. The passage of the bill would have involved such serious financial considerations to the cement manufacture of California that all the available information on the subject was brought together at the hearing held for the purpose, subsequently amplified by animal experimentation, etc., under the direction of Dr. George E. Tucker, in behalf of the Riverside Cement Co.[1] A brief was presented by Dr. Tucker, which includes a review of the literature on the subject, the results of the original investigation, including hospital records, anthropometric data, physical examination of employees, with reference to time employed and dust exposure, etc. The investigation was extended to include an original inquiry into the records of California public hospitals and other public institutions for the purpose of ascertaining whether an undue number of patients were being treated on account of tuberculosis possibly contracted in the cement industry, but the evidence was quite negative. The evidence of Dr. Tucker was subsequently presented in the form of a brief discussion on the "Physical examination of employees engaged in the manufacture of Portland cement," read before the American Public Health Association in 1914. Dr. Tucker presented a typical analysis of the raw mix or crude material which enters into the composition of cement, as follows: "Silica, 15.18 per cent; iron alumina oxide, 5.06 per cent; calcium carbonate, 76.34 per cent; magnesium carbonate, 2.90 per cent; undetermined, 0.52 per cent." In contrast to the foregoing, the finished cement shows the following analysis: "Silica, 22.98 per cent; iron alumina oxide, 8.80 per cent; lime, 63.10 per cent; magnesium oxide, 2.42 per cent; sulphuric anhydride, 1.42 per cent; loss on ignition, 0.52 per cent; undetermined, 0.69 per cent." The difference in the silica content is of considerable practical importance, as well as the very high proportion of lime, which, of course, is readily soluble. Tucker quotes Kehmann, of Wurzburg, to the effect that investigations have demonstrated that "most inspired dust finds its way into the stomach and not into the lungs; and most of the dust which enters the upper respiratory tract is caught by the moist mucous membranes of the nose and throat and the dust-laden secretion is then swallowed." It is further stated that—

> In the case of insoluble particles the gastrointestinal path may furnish a most satisfactory channel for the consequent elimination of the dust from the body, but soluble dust finds a peculiarly favorable

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[1] According to a report made to the State Department by Consul General John P. Bray, of Sydney, New South Wales, a labor controversy has developed between the local cement manufacturers and the wharf laborers at Sydney over the handling of cement in bags, the dust from which, it was claimed by the laborers, was injurious to health. On account of a virtual refusal to handle bagged cement in a form involving considerable dust exposure it is stated that the local cement company, with an approximate output of 30,000 bags per week, made a trial shipment of cement in bags lined with paper, but it was found that the cost of such bags was practically prohibitive, and that efforts would be made to have the bags produced by machinery at a material reduction in cost. No evidence is available as regards the success or failure of this experiment or whether a continued refusal to handle cement in ordinary bags has led to further labor difficulties. It is pointed out, however, that since paper bags are produced which are impervious to coal dust it should not be impossible to produce bags impervious to cement dust.

chance for absorption along the same route, and the opportunity for chronic intoxications is thus easily established. In any event, the lungs escape the major part of the initial irritation.

CHEMICAL ASPECTS OF CEMENT DUST IN RELATION TO DISEASE.

The application of this conclusion to the cement-dust problem is of exceptional practical importance. It is pointed out by Dr. Tucker that it would appear that, since the principal ingredient of cement is lime in the form of calcium oxide, undoubtedly this material is dissolved in the stomach and converted into lime water, which must be considered to be without injurious effects, since the hydrochloric acid of the stomach would undoubtedly be able to convert the oxide into the chloride, and that this material can be ingested in large quantities over long periods of time without ill effects. Laboratory tests show, according to Tucker—

That 99.7 per cent of five-tenths of a gram of cement is soluble in 500 c. c. of a one-tenth per cent solution of hydrochloric acid, and 99.7 per cent of five-tenths gram of cement is soluble in 250 c. c. of a two-tenths per cent solution. The average per cent of hydrochloric acid varies from one-tenth to two-tenths per cent in the gastric juices of the normal stomach. Similar experiments conducted in the laboratory, using the so-called treater dust, or dust which escapes from the stacks of the kilns heated to 800° C., showed that 81.44 per cent of five-tenths of a gram was soluble in 100 c. c. of a one-tenth per cent solution of hydrochloric acid. This solution became neutral when reaction was complete.

MECHANICAL ASPECTS OF CEMENT DUST IN RELATION TO DISEASE.

These conclusions are important not only to the cement industry but to many similar employments involving a continuous and considerable inhalation of mineral dust. There have been no other extended studies of this aspect of the dust problem, although the results would be of much practical value to the industries concerned. Apparently strictly scientific and impartial investigations in California public institutions, as well as among the employees of the Riverside Cement Co., show a remarkable rarity of pulmonary tuberculosis. The results of the investigation are summarized in the statement that "the membrane of the nose seems to exercise its complete function and eliminate the dust from the inhaled air." Since the cement dust is practically sterile and chemically nonirritating there is very little inflammation caused by its presence in the nose. The results of the physical examinations of employees were subsequently confirmed by animal experimentation. Out of 956 employees physically examined 7.2 per cent were found to be in bad physical condition, while the proportion in this condition among 544 applicants for employment was 7.7 per cent. Since a large proportion of the employees and applicants for employment were Mexicans and Armenians, the nativity factor naturally complicates the results. The average age of the employees was 31 years 8 months, the average height was 5 feet 6¼ inches, and the average weight was 149¾ pounds. The physical condition of the applicants for employment in these respects was much the same.[1]

PHYSIQUE OF CEMENT WORKERS.

In further explanation of the physical examinations it is stated by Tucker that—

> It should be understood that the men called "employees" were not selected risks and underwent no physical examination prior to employment, nevertheless the average weight of employed men was the same as the average weight of the applicants for employment. The average age of employees in the packing house was 29 years 4 months 23 days; the average weight, 153⅓ pounds; the average height, 5 feet 6½ inches. The average weight of men employed in the packing department was about 4 pounds more than the average weight of all men employed. This is based on the examination of 73 men who had been employed an average of more than two years. In the dusty parts of the mill figures show an average age of 31 years 6 months; average weight, 162 pounds; average height, 5 feet 6¾ inches. This is an average weight of 13 pounds more than general average, and is based upon the examination of 106 men employed for more than an average of two years.

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[1] The only trustworthy information regarding the physique of Mexican laborers in this country is made available through an analysis of height and weight of 1,112 applicants for industrial insurance with the Prudential, during the period 1908–1916. Most of these applicants at the time were residents of southern California. The average height of the Mexicans (see table below) was 66 in., against 68.5 in., in accordance with the medico-actuarial standard. The average weight was 146 lbs. for the Mexicans, in comparison with an average of 156 lbs., according to the medico-actuarial standard. The adjusted relative weight was 2.2 lbs. per inch of height for the Mexicans, against a standard of 2.3 lbs. Tho average Mexican is, therefore, 2.5 in. below the average American standard of height and 10 lbs. below the average American standard of weight. From such investigations as have been made regarding the mortality of Mexican laborers in this country, it appears that the frequency of pulmonary tuberculosis among them is decidedly common.

Comparative Anthropometry of Mexican Males.

[Applicants for industrial insurance, experience of the Prudential, 1908–1916, and standard American males according to the medico-actuarial investigation.]

Age.	Average height (inches).		Average weight (pounds).		Relative weight (pounds per inch).	
	Mexicans.	Medico-actuarial standard.	Mexicans.	Medico-actuarial standard.	Mexicans.	Medico-actuarial standard.
15 to 24 years	66	68.3	139	147	2.1	2.2
25 to 34 years	67	68.5	147	155	2.2	2.3
35 to 44 years	67	68.5	153	161	2.3	2.4
45 to 54 years	67	68.5	153	165	2.3	2.4
55 to 64 years	66	68.4	[a]145	165	2.2	2.4
65 years and over	65	66.5	[a]157	166	2.4	2.5
15 years and over	66	68.5	146	156	2.2	2.3

[a] Cases too limited in number for safe conclusions.

It would therefore appear that the employment was not physically injurious to the extent of a loss in weight, but rather, to the contrary, a gain resulted among the men exposed in the most dusty parts of the mill.

INFREQUENCY OF PULMONARY TUBERCULOSIS.

Among all the employees there were only 16 cases of suspected tuberculosis and but two of these had worked in any dusty part of the mill. The employment of these two covered a period of 1 and 10 days, respectively; but others had worked either in the quarry or yard, departments in which there could be no substantial exposure to cement dust, and the average length of employment of these was four and one-half months. Among the applicants seven had physical signs indicative of previous tuberculosis, so that even among the 16 cases previously referred to, it is a safe assumption that a fair proportion at least had contracted the disease before employment. The results of the investigation are summed up in the statement that—

> In conclusion, as a result of an investigation of the dust problem in conjunction with the manufacture of Portland cement, based upon the review of literature on the subject, the examination of 956 employees in one plant, examinations of men employed in the dusty departments of four other mills, the medical records of employees and guinea pig experimentation, there appears to me to be no evidence of injurious effects from cement dust upon employees engaged in its manufacture. The reexamination of all employees and the continuation of the records will give us information of more value, and annual reports of the results of the work at the Riverside Portland cement plant will be available to any one interested in this most important phase of the cement industry.

The California investigation has been referred to at length, in view of its exceptional practical importance. It is one of the most thoroughgoing efforts to ascertain precisely and conclusively the possibly health-injurious conditions in a leading American industry. Whether the conclusions are accepted or not, the method of inquiry itself is deserving of special recognition, particularly in view of the fact that the medical and statistical research was amplified by animal experimentation.

PROBLEMS OF DUST CONTROL.

In the case of the cement industry the problem is both simple and complex. The enormous quantity of dust which is itself the product of the industry must theoretically be assumed to be injurious to health and a predisposing cause of respiratory and possibly tuberculous diseases. Hirt, in the early seventies,[1] presented data according to which the proportionate morbidity from phthisis was only from 8 to 10 per cent among cement makers, against 80 per cent among flint workers, and 70 per cent among needle polishers. The industry in the meantime, however, has undergone such profound changes that these earlier observations are not of practical significance. Koelsch, in a more recent German contribution on mortality in relation to tuberculosis,[1] refers briefly to cement dust as injurious, but without sufficient statistical evidence to sustain his conclusions. His data, derived from the mortality of Bavaria for the year 1898, are limited to four deaths of cement workers out of a labor force of 1,267 exposed to risk. The resulting mortality rate of 3.16 per 1,000 compares favorably with 3.07 for all occupations, but the number of deaths is too small for final conclusions. More trustworthy observations are brought forward in the report of the chief inspector of factories and workshops of the United Kingdom for the year 1911 (p. 183), who remarks as follows:

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[1] Die Staubinhalations-Krankheiten, by Dr. Ludwig Hirt, Breslau, 1871, p. 30.

> Cement making has for years been regarded as one of the specially dusty trades in which difficulty has been experienced in confining the dust within reasonable limits during the processes of manufacture, grinding, and packing. The dust, however, has been held by some authorities as "not so damaging to health as might have been expected," though by others it is considered to cause "slight bronchial and lung troubles as well as catarrh of the stomach and inflammation of the eyes."

Modern processes, it is pointed out, have, however, had a tendency to materially reduce the quantity of dust which was formerly allowed to escape into the atmosphere. On the basis of a careful inquiry among friendly societies insuring persons employed in the cement industry the conclusion was arrived at that—

> These appear to show that the trade is on the whole a healthy one; that deaths are few; that absence from work is rare and generally due to influenza, colds, or accidents; and that there is often more invalidity among workers in nondusty processes than in the dusty occupations of kiln drawing, milling, and packing.

NONINJURIOUSNESS OF LIME DUST.

The general conclusion was, therefore, advanced, after a careful special inquiry into actual working conditions, that "while the dust is not of an injurious nature, probably owing to the fact that free silica is present in very small quantities, usually less than 1 per cent, it does cause irritation and trouble in some cases, and if not injurious it is at least a nuisance, and efforts should be made to prevent and reduce the escape of dust wherever practicable." This view has the indorsement of a letter in the British Medical Journal for May 7, 1900, in which, following a reference to the general conclusion that all dust is more or less seriously injurious to health, it is said that "a decided exception should be made in favor of lime dust." In the writer's personal experience "those breathing it habitually at limekilns are free from tuberculosis, and a similar observation has been made in France and Germany." Furthermore, it is said that "lime dust in abundant quantity, either by acting on the body or on the tubercle bacillus outside of the body, is antagonistic to tuberculosis." This conclusion would seem to have much in its favor, and, while not entirely sustained by the available insurance mortality statistics, the data at least indicate a relatively lower incidence of pulmonary tuberculosis than is common to the obviously more hazardous dusty trades.

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[1] Arbeit und Tuberkulose, by Dr. med. Koelsch, published in Archiv für Soziale Hygiene, Vol. VI, pp. 29, 212, 276; Leipzig, 1911.

MORTALITY OF CEMENT WORKERS—INDUSTRIAL INSURANCE EXPERIENCE.

Table 89 shows the industrial mortality experience among cement and lime workers as recorded by the Prudential Insurance Co. for 1897 to 1914. Of 222 cement and lime workers who died during that period, 16, or 20.7 per cent, died from pulmonary tuberculosis.

TABLE 89.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG CEMENT AND LIME WORKERS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, COMPARED WITH THAT OF ALL MALES IN UNITED STATES REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of cement and lime workers, 1897 to 1914, from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Cement and lime workers.	Males in registration area, 1900 to 1913.
15 to 24 years	18	2	11.1	27.0
25 to 34 years	40	15	37.5	30.5
35 to 44 years	48	12	25.0	23.4
45 to 54 years	45	10	22.2	14.7
55 to 64 years	49	6	12.2	7.9
65 years and over	22	1	4.5	2.6
Total, 15 years and over	222	46	20.7	13.9

The data are particularly suggestive at ages 25 to 34, when out of 40 deaths from all causes 15, or 37.5 per cent, were from pulmonary tuberculosis, against 30.5 per cent expected on the basis of the mortality data for the males of the registration area.

The American cement industry has within recent years attained to such nation-wide importance that the preceding considerations are applicable to a labor problem which at any time may assume serious significance, as made evident by the proposed measure in California aimed at the regulation of the industry by exceedingly drastic methods, as regards the impervious packing of the product, not with reference to the men engaged strictly in cement-making processes but solely for the protection of men employed in the subsequent handling of the finished product while in course of transportation. This suggests future possibilities which make it exceedingly important that the facts concerning the injuriousness or noninjuriousness of cement dust should be ascertained with impartial and strictly scientific accuracy. Cement is produced in practically every State of the United States, although the principal centers of production are Pennsylvania, Indiana, New York, Illinois, California, Missouri, Michigan, Iowa, New Jersey, and Kansas. These 10 States in 1914 produced 82.6 per cent of the aggregate output, and there are no reasons for believing that a material change occurred during more recent years. How far local and important variations in the chemical and mechanical properties of cement dust may affect the preceding conclusions regarding the apparent noninjuriousness of the dust in its relation to pulmonary tuberculosis can not be stated at the present time. As observed by Kober and Hanson in their treatise on "Diseases of Occupation and Vocational Hygiene," the manufacture of Portland cement varies in different countries, and they remark that—

> In England, where chalk is plentiful, this is used in connection with some material containing silica and alumina, such as selected clay or river mud. The raw materials are mixed in certain proportions and ground together to the consistency of liquid mud. The excess of moisture is driven off by heat, and the residue is dried in ovens at a high temperature. The preliminary process, while sloppy, is not dusty work, but the subsequent grinding between rollers and the sacking and packing of the product is an extremely dusty process. According to Koelsch and other German authors catarrhal affections and diseases of the respiratory organs constitute from 30 to 40 per cent of all the sickness. Diseases of the eyes and ears, impacted ear wax, ulceration of the nose with perforation of the nasal septum, and eczema, or cement itch, are also quite common.

Kober refers to a report made by Wittgen with reference to the results obtained in German cement works in the direction of dust removal and in consequence of which respiratory diseases were reduced fully one-third within a period of five years after the installation of exhaust ventilation, and the number of days lost by sickness was reduced proportionately. Further investigations of a more involved scientific nature are essential to the purpose of determining more conclusively the facts of a controversy, which is of importance not only to the cement industry of this and other countries, but also to every occupation involving more or less exposure to inorganic dust.

GENERAL CONCLUSIONS.

On account of the common occurrence of pulmonary tuberculosis under all labor or industrial conditions, it is self-evident that no crude statistical analysis of this kind can precisely measure the health-injurious effects of any particular occupation, trade, or industry. At best such data are only of approximate value, unless the incidence of pulmonary tuberculosis is so pronounced as to justify unqualified conclusions. In the case of cement dust it is apparently shown that the results, if serious at all, are much less so than in the case of most of the other dusty trades considered. It is difficult to accept, without due reserve, the conclusions advanced by Tucker in their entirety, and particularly his statement that "outside of the packing room and the sack-cleaning room there is no department in which cement dust escapes into the atmosphere in any appreciable quantities." It may be stated with confidence that practically all branches or departments of cement manufacture involve considerable exposure to the dust hazard, and while the evidence may be wanting that cement dust is a predisposing cause of tuberculosis, there can be no question but that certain forms of respiratory affections are relatively common, at least among certain classes of employees. In the entire absence of official vital statistics for the States and sections in which the cement industry is represented by a sufficiently large number of employees, it would seem of sufficient importance to suggest that special inquiries should be made in the more important centers of the cement industry in conformity to the admirable methods of scientific investigation developed by the Riverside Cement Co.

BRICK, TILE, AND TERRA-COTTA MAKERS.

These occupations are too complex to permit of a satisfactory analysis of the available mortality data which, almost without exception, are quite general and do not refer to specific industries or employments. The dust hazard necessarily varies widely in an industry of such vast extent and which is carried on under such varying conditions. Brickmaking has during recent years undergone material changes on account of the extensive introduction of machinery. It is estimated by Mr. W. Frank M'Clure in the Scientific American for October 7, 1905, that one machine employed in extricating processes accomplishes the work of 75 men. The same writer explains that—

> After coming from the pug mill the pasty material is cut into the shape of bricks by machinery which works automatically, and modern methods also provide for the use of exhaust steam and heat from the kilns for the heating of the drying house.

BRICKMAKING PROCESSES.

The processes of brickmaking in general are described with admirable brevity by this writer, as follows:

> From the cars the clay and shale are shoveled into grinders, which reduce these two products to a powder, which in turn is carried by a bucket elevator to a big hopper. After it has been sufficiently screened the powdered clay and shale next go to the pug mill, that which will not pass the screen going back to the grinders again. In the pug mill—a sort of conical trough—the raw material is tempered with water and kneaded by means of a device somewhat resembling a screw propeller in shape. From this mill it is forced through a mold into one long, continuous brick, and this, as it comes from the mill, is carried on a wide belt to a cutting machine, which automatically cuts the continuous brick into many bricks of the desired size, the machine cutting 16 bricks at one time. As the bricks come from the cutting machine, still soft and still resting on the belt, they are loaded onto flat cars and removed to the drying house, where they remain not less than a day and night. The capacity of a large drying house is about 100,000 bricks. The different apartments of this house are brick lined.
>
> The brick next go to the kilns for baking. One of the engravings gives a good idea of the manner in which these brick are piled within the kilns. Five or six men often work three full days in filling one kiln, which fact gives some idea of the size of the interior. After the entrance to the kiln has been closed and sealed the fire beneath is started. The baking process is then continued for 9 or 10 days, the temperature maintained within being 2,300° F. Then, when the kiln has been cooled, the bricks are taken out and are ready for shipment. Where 15 or 16 kilns are in use the daily capacity of ordinary-sized brick may reach 150,000.

HEALTH-INJURIOUS CONDITIONS.

In all of these processes there is a considerable degree of dust exposure, the injuriousness of which, however, is materially reduced by the fact that most of the operations are carried on in the open air. The evidence presented to the departmental committee on industrial diseases by Dr. Chalmers was to the effect that brickmaking could not be considered a healthy occupation. The same conclusion had been arrived at in the earlier investigation into the experience of the British Friendly Societies reported upon by Radcliffe. Apparently the most injurious processes are in connection with the molding, drying, and burning, where the dust exposure is occasionally quite considerable, in that the dust is reduced to an extremely dry and finely powdered condition. The process of manufacture with special reference to tempering, molding, drying, and burning has been described by Mr. T. C. Naulty, inspector of the Underwriters' Association of New York, in the Weekly Underwriter, for June 4, 1910. The only comparatively recent investigation into the sanitary conditions of brick and tile making, with special reference to grinding and mixing is by Hayhurst.[1] This investigation included 9 establishments in the State of Ohio, employing 67 workers in the processes of grinding and mixing. In only two instances, however, were health appliances, such as blowers, etc., present, it being observed that boxed-in chutes rendered much aid in limiting the dust. Only 5 of the 67 employees were over 40 years of age. It is said by Hayhurst that—

> The chief objectionable features to this process, from a health point of view, were the breathing of clay dust, and the red coloring compound often mixed with it, the dirt underfoot, the dampness, and, for cooler weather, the absence of heating arrangements, all of which were fair to bad hazards. In two places the work was housed in so that the light was poor, and a similar condition existed for ventilation in two places. In one place the mixing machine was so close to a kiln that the workers were affected by the heat. In all places there was a moderate risk of overfatigue, not so much from laborious work, which was not the rule, but from monotonous application, constant standing, and the loud noise from the grinding machine.

NEGLECT OF SANITARY PRECAUTIONS.

It is further pointed out by Hayhurst that the liability of contracting communicable diseases was found to be bad in all the places investigated, except in one, due to promiscuous spitting into the dried-up clay dust on the floor, the absence of cuspidors, and the lack of proper washing facilities. It is stated, however, that the outdoor character of the work in most places mitigated against this hazard, but attention is directed to the risk of contracting hookworm disease on account of the primitiveness of the sanitary arrangements.

GRINDING, MIXING, AND PRESSING.

The general appearance of the workers was found to be good in only 40 per cent of the cases observed, but none of the men seen presented a decidedly sickly appearance. The concluding observations with reference to grinding and mixing are to the effect that—

> These workers, as well as the rest of those in brick and tile works, should be provided with proper sanitary and drinking facilities because of the risk of typhoid fever and hookworm disease. Workers predisposed to lung troubles should not engage in any part of the brick industry. For certain intervals of very dusty work the workers should put on respirators. Grinding and mixing processes everywhere could be rendered entirely dustless for the places in which the workers are required to remain, as was observed to be the case at one plant.

The same investigation included the pressing process, which follows the grinding and mixing, and which, in general terms, is almost entirely mechanical. This investigation included nine establishments, employing 200 men, of whom only 1 was over 50 years of age and 5 per cent were under 20 years. Dust from the drying of wet clays under foot was found to be a bad feature in three places, and fairly so in three others, while in two places it was negligible; but in one large place the dust was so thick in the air "that one could scarcely see 30 feet." In six of the nine places the work was damp enough to be considered hazardous, and workers were found to be unable to keep dry, especially with the forms of footwear and clothing used. In six places there seemed to be a number of factors productive of fatigue. The general conclusions were of much the same effect as previously stated with regard to grinding and mixing.

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[1] Industrial Health Hazards, 1915.

KILN SETTING, FIRING, AND DRAWING.

Work at the kilns was investigated at nine establishments employing 116 men in setting, firing, and drawing the kilns of brick and sewer pipe. There were found to be no appliances which could be considered as having to do with the conservation of health, nor were there found to be any instructions or placards suggestive of qualified advice in this direction. Of the 116 men, practically all unskilled laborers, 14, or 12.1 per cent, were over 40 years of age. According to Hayhurst—

> The chief hazards of this process were exposure to heat, alternating with weather conditions. This seemed bad in 3 places, and some hazard in all of the remaining. It depended somewhat upon the methods of drawing the kilns. In some places workmen were put upon them while the temperature was yet extremely hot. In one place premises around the kilns were kept very neat and clean. As elsewhere in this industry, fatigue factors were present, and probably more so in this process than any other. Arranged in descending order, as nearly as possible, these were: Monotonous application, with constant standing for long periods, hurrying piecework, with evidence of speeding up, laborious work under considerable strain, pressure against the body, and long hours.

In conclusion it is said that the appearance of the workers was generally good in most places, but some were found who complained of their health and others who appeared to be in a decidedly inferior physical condition. The conclusion advanced is that "This is a process requiring hard, laborious work at intervals, but this should not proclaim it necessarily unhealthy, provided the many other features mentioned were not present to menace the health of the workers." These observations are far from conclusive and they only indirectly bear upon the question as regards the relative frequency of tuberculosis in consequence of undue exposure to health-injurious conditions. The conclusion, in the main, however, indicates labor conditions far from satisfactory and, broadly speaking, probably predisposing to general ill health. These conclusions apply also, in a general way, to terra-cotta workers and tile makers, at least as regards some of the processes, which are more or less identical with brickmaking, but to a less extent than to brickmakers who in addition, of course, are exposed to numerous other health-injurious conditions, such as the risk of inhaling lime or mortar dust, especially in brick-cleaning processes and the taking down of old walls, etc.

MORTALITY OF BRICK AND TILE MAKERS—UNITED STATES REGISTRATION AREA.

The mortality of brick and tile makers has been reported upon only for the year 1909 by the Division of Vital Statistics of the United States Census Bureau, and no subsequent information has been made public, so that the data are of rather limited value. According to the census report out of 133 deaths of brick and tile makers from all causes 16, or 12 per cent, were from pulmonary tuberculosis. The details of the mortality, by divisional periods of life, are shown in Table 90.

TABLE 90.—PROPORTIONATE MORTALITY OF BRICK AND TILE MAKERS FROM PULMONARY TUBERCULOSIS, UNITED STATES REGISTRATION AREA, 1909, BY AGE GROUPS.

Age at death.	Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent of deaths from all causes.
15 to 24 years	14	3	21.4
25 to 34 years	13	3	23.1
35 to 44 years	18	5	27.8
45 to 54 years	20	3	15.0
55 to 64 years	26	2	7.7
65 years and over	41		
Age unknown	1		
Total, 15 years and over	133	16	12.0

TABLE 91.—PROPORTIONATE MORTALITY OF BRICK AND TILE MAKERS FROM NONTUBERCULOUS RESPIRATORY DISEASES, UNITED STATES REGISTRATION AREA, 1909.

Cause of death.	Deaths from nontuberculous respiratory diseases.	
	Number.	Per cent.
Asthma		
Bronchitis		
Pneumonia	8	6.0
Other nontuberculous respiratory diseases	2	1.5
Total	10	7.5

The number of deaths under observation is too limited for entirely safe conclusions, but in a general way the table is sustained by insurance experience and foreign data. The proportionate mortality from pulmonary tuberculosis is below the average for all occupied males at ages under 35 and only slightly above the average at ages 35 and over. It may be said that the mortality of brick and tile makers from pulmonary tuberculosis approaches so closely to the normal for all occupied males that there are apparently no decidedly health-injurious conditions in this employment predisposing to pulmonary tuberculosis, and, as shown by Table 91, to nontuberculous respiratory diseases. The proportionate mortality from this group is 7.5 per cent for brick and tile makers, which compares with 10 per cent for all occupied males and 9.2 per cent for glassworkers.[1]

MORTALITY OF BRICK, TILE, AND TERRA-COTTA MAKERS—INDUSTRIAL INSURANCE EXPERIENCE.

Additional statistical data as shown in Table 92 are available for this group of employments through the industrial mortality statistics of the Prudential Insurance Co. of America for the period 1897 to 1914, including 527 deaths from all causes, of which 82, or 15.6 per cent, are from pulmonary tuberculosis.

TABLE 92.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG BRICK, TILE, AND TERRA-COTTA MAKERS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, COMPARED WITH THAT OF ALL MALES IN UNITED STATES REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of brick, tile, and terra-cotta makers, 1897 to 1914, from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Brick, tile, and terra-cotta makers.	Males in registration area, 1900 to 1913.
15 to 24 years	48	11	22.9	27.0
25 to 34 years	51	18	35.3	30.5
35 to 44 years	81	16	19.8	23.4
45 to 54 years	97	18	18.6	14.7
55 to 64 years	121	13	10.7	7.9
65 years and over	129	6	4.7	2.6
Total, 15 years and over	527	82	15.6	13.9

The proportionate mortality is relatively high at all ages, but not excessively so when compared with more decidedly health-injurious processes with exposure to metallic and more irritating mineral dust.

The corresponding industrial mortality experience of the Metropolitan Co. is limited to masons and bricklayers considered as a group. It includes 1,748 deaths from all causes. Table 93 is derived from Bulletin 207 of the Bureau of Labor Statistics, on "Causes of Death by Occupation."

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[1] For earlier references to the health of brick makers, see the Journal of Health, Vol. II, page 286, and the Comparative Rates of Mortality in Various Occupations, pages 11, 27, and 45. For modern observations on the health of brick makers with special reference to health-injurious conditions, see the English report on Industrial Diseases, 1907, evidence by Chalmers, page 4304.

TABLE 93.—NUMBER AND PER CENT OF DEATHS FROM SPECIFIED CAUSES AMONG MASONS AND BRICKLAYERS, BY AGE PERIODS, 15 YEARS AND OVER—WHITE MALES.

[Metropolitan Life Insurance Co.—Industrial department—Mortality experience, 1911 to 1913.]

Cause of death.	Ages 15 years and over.		Per cent of deaths during age period (years)—					
	Number.	Per cent.	15–24	25–34	35–44	45–54	55–64	65 and over.
Number of deaths	1,748	....	59	124	250	327	475	513
Tuberculosis of the lungs	332	19.0	28.8	45.2	42.0	26.6	10.5	3.3
Cancer (all forms)	113	6.5	....	1.6	2.8	4.6	10.3	7.8
Alcoholism	18	1.0	....	2.4	1.6	1.8	.4	.6
Cerebral hemorrhage, apoplexy, and paralysis	136	7.8	....	.8	2.4	2.4	12.2	12.3
Organic diseases of the heart	227	13.0	3.4	6.5	8.0	9.2	14.7	18.9
Acute and chronic bronchitis	18	1.0	....	.8	....	.6	.6	2.3
Pneumonia (lobar and undefined)	132	7.6	10.2	7.3	6.0	10.1	6.7	7.2
Cirrhosis of the liver	34	1.9	....	.8	2.0	1.8	2.9	1.6
Bright's disease	178	10.2	5.1	3.2	5.6	10.1	12.2	12.9
Suicide (all forms)	29	1.7	1.7	.8	1.2	1.5	1.9	1.9
Accidental violence	133	7.6	25.4	8.1	9.2	9.8	5.7	5.1
All other causes	398	22.8	25.4	22.5	19.2	21.5	21.9	26.1
Total	1,748	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[1] This title includes foremen and workmen: stonemasons, bricklayers, masons, bricksetters, tile layers, and plasterers.

This table includes a number of other specified causes of death, but throughout the most important disease is pulmonary tuberculosis, which accounts for 19 per cent of the mortality from all causes at ages 15 and over, and as much as 45.2 per cent of the mortality at ages 25 to 34. As observed by Dr. Dublin in his interpretation of the table, "the United States figures, the English figures, and those of the Prudential Insurance Co., all confirm the occurrence of rising relative indices in successive periods up to age 65, suggesting a direct causal relationship between tuberculosis of the lungs as a cause of death and the duration of service in this occupation." The inherent limitation of all data of this character is due, however, to the inclusion of widely varying employments in a single group, which rather requires the highly specialized consideration of carefully segregated branches or specific occupations to determine the true incidence of health-injurious conditions.

POTTERS.

The pottery industry includes the manufacture of earthenware, china, and porcelain. It always has been recognized as one of the unhealthiest of trades, but the health-injurious effects vary widely according to particular employments. The most seriously exposed are the dippers, flint-mill workers, ground layers, mixers, scourers, and sweepers. In all of these employments except the first the exposure to health-injurious mineral dust constitutes a serious menace to health. In the case of dippers the liability to dust inhalation is modified and increased in seriousness by the risk of lead poisoning. The degree of dust exposure is also very serious in the case of kilnmen, mold makers, placers, pug-mill workers, sagger makers, and slip makers. In the aggregate the industry gives employment in the United States to about 26,000 persons, of whom one-fifth are women. The sanitary conditions of the trade have often been investigated, and the most recent evidence is to the effect that there have been material improvements within the last few decades. The most careful and useful observations of the industry were made by Arlidge, who for many years lived in the Staffordshire pottery district of England. Before quoting Arlidge the fact may be briefly referred to that as early as 1705 Ramazzini, in commenting upon the diseases of potters, pointed out that "not all who go by the name of potters are subject to the particular disease of the trade," and that, therefore, discrimination was necessary in the medical treatment of the different classes of employees. Ramazzini made a curious observation bearing upon the question of eye strain, which has received qualified consideration only within recent years, stating, with reference to potters, that "those who sit at the wheel and form the vessels by turning it about with their feet are apt to have a swimming in the head if their eyes are otherwise weak."

SANITARY ASPECTS OF THE POTTERY INDUSTRY.

Arlidge, in discussing the effects of mineral dust in the manufacture of pottery before the Sanitary Institute in 1893, remarked at the outset that—

> Scarcely any other manufacture has so strong a claim upon the attention of sanitarians as has that of pottery. It stands nearly at the head of the list of unhealthy occupations, and exercises its pernicious effects almost wholly upon the respiratory organs, by production of bronchitis and of consumption. Thus it is found that while workmen engaged in other employments have a mortality from chest diseases of 7.86 per cent, potters exhibit one of 12.29 per cent. Likewise with respect to phthisis—nonpotters present one of 9.27 and potters one of 12.90.

After describing the various processes of manufacture and their relation to health-injurious circumstances, Arlidge discussed the relation of clay dust and its irritating effects upon the mucous membrane and epithelium of the lungs, holding the opinion that—

> Clinical observation abundantly confirms this fact. For a considerable time the inhaled dust is arrested in its advance toward the lung tissue proper by the mucous secretion in the bronchial tubes, and by the expulsive energy of the cilia lining of those tubes. But at length these resistant forces weaken before the constant entry of fresh

dust, and in course of time the noxious material passes into the lymph channels, and also along the finer bronchi, until it reaches the intimate structure and the air cells themselves. Here as a foreign substance it sets up inflammatory action; lymph cells spring up, the air vesicles become choked with inflammatory products, the tissue around them gets indurated (lung sclerosis), and useless as breathing tissue.

The history of these pathological changes is reflected in the symptoms exhibited by the sufferers. In the primary stage little inconvenience is felt; there arises a desire to clear the throat of some impeding mucous at the end of the day's work, or upon transition to the outer air from the warm shop, and especially on rising in the morning. This expulsive act soon develops into a cough, and relief is obtained by the expectoration of more or less blackish viscid mucus. Presently there is a feeling of tightness in the chest, and the breathing grows less free and full. As time goes on these signs of disturbed lung function become more pronounced, and in the end the patient grows asthmatic—a victim of potters' asthma.

Until this advanced stage of disorder is reached it is singular to notice how little attention and anxiety are bestowed upon the pulmonary derangements. This is because the general health is, for the most part, not seriously affected, and inasmuch as while the sufferer breathes a warm air in his workshop or home, his lung trouble is felt as little more than an annoyance; or as something which is to be taken as a matter of course, and, like his wages, as an unavoidable incident of his calling.

As with chronic maladies at large, so with potters' bronchitis and asthma, the tendency is to grow worse and the lung lesion to extend, and soon the damaged respiration reacts upon the whole frame; the sufferer can not get proper outdoor exercise, his appetite fails, his sleep is broken, the expectoration augments and grows muco-purulent, the body wastes slowly, while the increased effort to breathe entails strain upon the heart, leading not infrequently to disease of that organ, with the after consequences in the shape of dropsical effusions. We now have before us the fully developed disease known as potters' consumption or potters' asthma.

EFFECTS OF SILICA DUST.

The injurious effects of clay dust in the pottery industry are further increased by minute particles of flint, and a possible additional factor injurious to health is the extensive use of plaster of Paris, employed in the making of molds and models. According to Arlidge, the effects of plaster of Paris dust, however, are not apparently as serious as the very destructive effects of silica dust and small particles of flint. He draws attention to the necessity of an efficient system of ventilation as the only means by which material improvements can be brought about.

LIABILITY TO LEAD POISONING AND PULMONARY DISEASES.

The health-injurious effects of lead, extensively used in potteries, which do not properly fall within the present discussion, must here be passed over.[1] It is true, of course, that a considerable amount of lead dust is inhaled, but the effects are rather upon the system generally than upon the lungs. The observations of Arlidge are so entirely sustained by other qualified observers that it is not necessary to further enlarge upon the sanitary aspects of this trade. The evidence, statistical or otherwise, is conclusive that potters as a class suffer more, perhaps, from phthisis and other diseases of the lungs than employees in any other occupation, and their mortality from bronchitis and other respiratory diseases is many times as high as the mortality of occupied males generally; but it has been pointed out by Tatham, in his contribution to Oliver's "Dangerous Trades," that—

> Potters succumb to nontubercular disease of the lungs much more rapidly than they do to tubercular phthisis; and it is certain that much of the so-called potters' phthisis ought properly to be termed cirrhosis of the lung. Deaths from this affection should never be included under the head of phthisis, which term is now restricted, by universal consent, to the tubercular malady of that name.

It is also necessary to keep in mind, in discussing the pottery industry, that it divides itself broadly into two principal departments—that is, first, the making of the articles from potters' clay, and, second, their ornamentation by painting, gilding, etc. The latter group of occupations is usually defined as decorators, and somtimes as printers, and because of this fact many errors occur in occupation statistics as the result of erroneous classification—not based upon the industry as such, but upon the specific title of the employment.

SPECIFICALLY INJURIOUS PROCESSES.

One of the most health-injurious employments in the industry is that of the brushing, or dusting off, of the ware after it is taken from the kilns. Oliver, in discussing at length the sanitary aspects of china and earthernware manufacture and in particular potters' asthma and pulmonary tuberculosis, draws special attention to this process as observed in the porcelain potteries at Limoges. He remarks that—

> The brushing off or époussetage of the fired or biscuited ware is done both by women and men by means of soft feather brushes. It is a very dusty operation, and where there are no fans for its removal, as in some of the factories I visited, the air was thick with dust. The windows were open at the time, but currents of air obtained by this

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[1] With respect to lead poisoning in the pottery trades see:

Departmental report on "The Pottery Industry in France," by Thomas Oliver, M. D. London, 1899.

Departmental report on "The Employment of Compounds of Lead in the Manufacture of Pottery," by Thorpe and Oliver. London, 1899.

Departmental report on "Lead in the Manufacture of Earthenware and China," Vols. I, II, and III. London, 1910.

Bulletin of the U. S. Bureau of Labor, No. 104, "Lead Poisoning in Potteries, Tile Works, etc.," by Dr. Alice Hamilton. Washington, 1912.

means exercised no very appreciable influence upon the dust. It is not this kind of ventilation that is required under these circumstances. In the matter of the provision of artificial means for the removal of dust and the renewal of air in the potteries of Limoges, some of the manufacturers seemed to me to be rather behind than in advance of the owners of large factories in Staffordshire. Accordingly I was not unprepared for the information that among the potters, especially the brushers off or scourers, in Limoges, the mortality from pulmonary consumption and chest diseases is high. The harmful operations in porcelain works are the emptying of the kilns, the removal of the ware from the saggers and the brushing of this ware, while the hard dust that rises during the polishing of the all but finished articles is equally dangerous. The polishing has for its object the removal of any roughness from the edges or surfaces of the ware, and it is generally done on a revolving wheel by means of a broken piece of china, the workman using this as a smoothing agent. The men and women employed in these operations are usually well covered with dust, yet it is seldom that they wear respirators. Fans for the removal of the dust were present in only very few of the factories. The employees objected to them on the ground that they created a strong draft of cold air. Dr. Raymondaud, one of the professors in the School of Medicine, Limoges, has made a special study of the diseases of porcelain makers, particularly of pulmonary consumption and chronic bronchitis. He found that the potteries furnished a larger number of patients suffering from lung diseases than did the other trades of the district. Of 75 deaths registered in Limoges as occurring among china makers, 36 were due to phthisis, and of 30 potters whom Raymondaud examined, 20 were suffering from pulmonary consumption. Pulmonary phthisis is regarded as the principal disease affecting the workers in the Limoges potteries.

ENGLISH OCCUPATIONAL MORTALITY STATISTICS.

The most recent English mortality statistics of potters are for the three years ending with 1902, referred to in the Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales, in part as follows:

Between the ages 20 and 35 years the mortality of potters falls below that of occupied and retired males generally; at every other age, however, it shows an excess which amounts to no less than 74 per cent at ages 45 to 55 years, and to 66 per cent at ages 55 to 65 years. In the main working time of life the comparative mortality figure is 1,493, or 49 per cent above the standard. The principal excess falls under the head of respiratory diseases, for which the mortality figure is 473, or nearly thrice the standard. There is also a considerable excess in the mortality from phthisis, from nervous and circulatory diseases, and from suicide. These workers are also specially liable to lead poisoning, but from accident as well as from influenza, Bright's disease, and alcoholism their mortality is low.

In the last decennial supplement the mortality of potters was described as enormous. From the present report, however, it will be seen that since 1890–1892 their mortality has declined at every stage of life; and in the main working period the comparative mortality figure has fallen from 1,970 to 1,420, or by no less than 28 per cent. It is satisfactory to note that in the recent period the mortality of potters from plumbism has fallen to less than half its former amount, while there has also been a substantial decline under most other headings; the mortality from respiratory and urinary diseases having fallen by about one-third, that from phthisis, nervous and digestive diseases by about one-fourth, and that from circulatory diseases by about one-fifth part. Potters, however, now fall victims in increased proportion to accident, and to suicide, and the mortality from cancer has increased by more than half. Since 1860, '61, '71 the death rates of potters both above and below 45 years of age have fluctuated somewhat, but the recent modified mortality figure is by far the lowest on record. Since 1880–1882 there has been a continuous decline of mortality from phthisis, from liver disease, and from diseases of the nervous and digestive systems.

The English statistics for potters are quite conclusive of the unfavorable effects of this industry on health. In Table 94 the mortality from all causes among potters is compared with that of occupied males generally, and the result is decidedly suggestive of conditions more or less unfavorable to life and health, but in particular at ages 35 or over, when the mortality rate from all causes exceeds by from 4.30 to 29.86 per 1,000 the corresponding mortality of occupied males generally.

TABLE 94.—MORTALITY FROM ALL CAUSES AMONG POTTERS, COMPARED WITH THAT OF ALL OCCUPIED MALES, IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[Source: Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 for all occupied males.	Death rate among potters.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	2.44	2.62	+ 0.18	107
20 to 24 years	4.41	3.68	− .73	83
25 to 34 years	6.01	5.26	− .75	88
35 to 44 years	10.22	14.52	+ 4.30	142
45 to 54 years	17.73	31.64	+13.91	178
55 to 64 years	31.01	54.15	+23.14	175
65 years and over	88.39	118.25	+29.86	134

The preceding table is self-explanatory. A more extended comparison, however, is made in Table 95, in which the mortality of potters from pulmonary tuberculosis and from other diseases of the respiratory system is compared with the normal mortality of occupied males from these diseases, by divisional periods of life. The comparison shows that the mortality from pulmonary tuberculosis among potters is decidedly excessive at ages 35 to 64 by from 1.05 to 4.10 per 1,000. Still more marked is the excess in the mortality from respiratory diseases other than pulmonary tuberculosis among potters at ages 35 or over, which varies from 1.63 to 17.27 per 1,000.

TABLE 95.—MORTALITY FROM PULMONARY TUBERCULOSIS AND FROM OTHER DISEASES OF THE RESPIRATORY SYSTEM AMONG POTTERS, COMPARED WITH THAT OF ALL OCCUPIED MALES, IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

Source: Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Mortality from pulmonary tuberculosis.				Mortality from other diseases of the respiratory system.			
	Death rate per 1,000 for all occupied males.	Death rate for potters.			Death rate per 1,000 for all occupied males.	Death rate for potters.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years.....	0.54	0.62	+0.08	115	0.24	0.46	+ 0.22	192
20 to 24 years.....	1.55	1.34	− .21	86	.48	.58	+ .10	121
25 to 34 years.....	2.03	2.00	− .03	99	.77	.64	− .13	83
35 to 44 years.....	2.74	3.79	+1.05	138	1.66	3.29	+ 1.63	198
45 to 54 years.....	3.04	7.14	+4.10	235	3.32	10.78	+ 7.46	325
55 to 64 years.....	2.16	4.37	+2.21	202	6.54	23.10	+16.56	353
65 years and over.	1.11	.97	− .14	87	17.77	35.04	+17.27	197

INVESTIGATIONS BY DEPARTMENTAL COMMITTEE ON INDUSTRIAL DISEASES.

With further reference, however, to the excessive mortality from respiratory diseases among potters, which, as subsequently to be shown, is confirmed by American industrial insurance mortality experience, reference may be made to the discussion of the occurrence of potters' asthma, in the Report of the Departmental Committee on Industrial Diseases. The evidence submitted to the committee disclosed a decided improvement in the disease liability of potters to the fibroid form of phthisis, based upon the records of the North Staffordshire Infirmary, at Stoke-upon-Trent, covering the period 1873–1906. Upon a basis of 10,000 patients, the number of cases of fibrosis of the lungs was found to have been 145 during the six years ending with 1878, 107 during the six years ending with 1897, and only 4 during the six years ending with 1906.[1] In the opinion of a qualified medical witness, the diminution was not the result of a difference in the practice of diagnosing, but a real reduction in the prevalence of the disease. The improvement in the disease liability was attributed to a betterment in the conditions of work and a more effective method of factory supervision, inspection, and control. Aside from these favorable conclusions, however, the general mortality statistics of this trade indicate continued unfavorable circumstances, reflected in the decidedly excessive degree of pulmonary tuberculosis frequency and a correspondingly excessive mortality from other respiratory diseases in the more advanced years of life.

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[1] Minutes of Evidence, Departmental Committee on Compensation for Industrial Diseases, London, 1907, p. 60.

DESCRIPTIVE ACCOUNT OF THE AMERICAN POTTERY INDUSTRY.

These preliminary observations are strongly indicative of an industry in which the dust problem is of exceptional importance in its relation to health and longevity. The aggregate value of pottery products in the United States in 1915 was nearly $40,000,000, or almost twice the value reported for 1901. The principal branches of manufacture are (1) red earthenware; (2) stoneware and Rockingham ware; (3) whiteware, including CC ware; (4) china, bone, delft, and belleek ware; (5) sanitary ware; (6) porcelain, electrical supplies: (7) miscellaneous. The number of active manufacturing plants in 1913 was 426. The principal pottery-producing States are Ohio, New Jersey, and West Virginia, which, combined, produce 76 per cent of the total product. The pottery industry has been admirably described in a report of the Bureau of Foreign and Domestic Commerce,[1] including descriptive accounts of the various special processes, with observations on methods and labor conditions in other countries. The principal departments of the industry are (1) preparation of materials; (2) forming the ware; (3) firing the ware; (4) decorating; (5) packing, etc. Each branch consists by itself of numerous and often highly specialized processes, which do not permit of being briefly described. Practically without exception, however, it may be said that all processes involve more or less dust exposure, the nature of which, of course, will vary considerably according to the product. As a general conclusion, based upon reasonably thorough investigations in this country and abroad, it may be said that the sanitary and other conditions affecting the health of potters in this country are decidedly better than those which affect the health of potters, for illustration, in England and Wales. The workshops in this country, as a rule, have a greater abundance of light and ventilation and more adequate provision for heating during the winter. The more extensive use of machinery, by which most of the very hard labor in mixing the clay and running the so-called jigger and jolly machines is largely done away with, is also a factor of considerable practical importance. On account of the specific liability to lead poisoning in the pottery industry, it is suggested that the proportion of lead used in the dipping processes in this country should be generally much less than in England and Wales. The climatic conditions in the United States are also in favor of a lower mortality rate from respiratory diseases resulting from weather exposure.[2]

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[1] The Pottery Industry. Miscellaneous Series, No. 21. U. S. Bureau of Foreign and Domestic Commerce. Washington, 1915.

[2] Lead Poisoning, by Sir Thomas Oliver. London, 1914.

DESCRIPTION OF PROCESSES ACCORDING TO DUST EXPOSURE.

The disease liability of employees in the various branches of the pottery industry in the United States, roughly approximated, is as follows:[1]

1. Office workers, dust exposure very slight and general conditions favorable.
2. General outside laborers, dust exposure slight, but general conditions often far from favorable.
3. Mixers of materials for glaze, etc., dust exposure very considerable, especially of clay, flint, and white lead.
4. Slip makers, pug-mill workers, etc., considerable dust exposure and dampness.
5. Mold makers, some dust exposure, chiefly to plaster of Paris.
6. Throwers, some dust exposure. Occupation is more or less obsolete.
7. Jigger men and jolly men, considerable dust exposure, but fairly favorable indoor conditions.
8. Pressers of hollow ware, some dust exposure, but fairly favorable indoor conditions.
9. Pressers of flat ware, some dust exposure, but fairly favorable indoor conditions.
10. Pressers of sanitary ware, a lesser degree of dust exposure, but occasionally considerable dampness.
11. Sagger makers, exposure to dust and dampness and frequently heavy physical strain.
12. Kiln men, placers, considerable exposure to flint dust and other unfavorable conditions.
13. Kiln men, drawers, considerable exposure to dust and frequently extreme heat.
14. China scourers, brushers (women), very considerable exposure to irritating flint and other dust.
15. Dippers and dipper helpers, exposure to risk of lead poisoning and much dampness.
16. Decorators, printers, and fillers-in, exposure to mineral poisons, lead poison, and atmospheric pollution on account of odor of turpentine.
17. Ground layers (decorators), very considerable exposure to risk of inhalation of dry dust of mineral paints.
18. Warehousemen, slight degree of exposure to inorganic dust.
19. Packers, considerable exposure to dust of straw and inorganic dust.
20. Sweepers, exceptionally serious exposure to flint and clay dust.

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[1] This list is based upon personal investigations into the pottery industry, chiefly in the States of New Jersey, Ohio, and West Virginia.

21. Flint-mill workers, considerable and continuous exposure to the most dangerous form of irritating flint dust.

These observations are only approximate, and it should be considered that the different employments are frequently carried on in conjunction with or in continuance of one another. The most exposed employments are those of china scourers, ground layers, sweepers, and flint-mill workers.

PATHOLOGY AND SYMPTOMOLOGY OF THE DUST PROBLEM.

The pathology and symptomology of the dust problem in the pottery industry has attracted the serious attention of all authorities on occupational diseases. A concise and exceptionally conclusive though very brief contribution to the study of lung sclerosis in porcelain workers was made by a French authority—Dr. Lemaistre—in Le Progrcs Medical and translated in the Medical Record for December 27, 1890, in connection with which it is stated that—

> Sections of the lung are generally colored, according to the material that has been introduced; but here the lung is blackish, although the substance introduced may be white, owing to inflammatory conditions. The symptoms are analogous to tuberculosis and the diagnosis is difficult. The posterior aspect of the lung is most frequently the seat of the sclerosis. Sometimes the sounds of pulmonary emphysema or of pleurisy may be heard. It is, however, differentiated from emphysema by the absence of tympanitic sounds. The sputa are characteristic. There is no hectic fever or nocturnal sweating. Men are more frequently attacked than women. He has found bacilli in the sputa and regards the disease as a tubercular fibrosis. The siliceous particles produce ulcerations in the bronchi, upon which the tubercular matter is grafted, and continues to exert an irritant action which induces hyperplasia of the connective tissue. This, to a certain extent, is salutary.

POTTERS' ASTHMA.

Partly in consequence of this condition inimical to the health of pottery employees generally the term "potters' asthma" has been widely accepted as typical of the highly specialized conditions under which respiratory affections resulting from continuous dust exposure in the pottery industry are likely to occur. In a measure potters' asthma resembles miners phthisis, but it is frequently indistinguishable from true tuberculous phthisis, without the preceding lung fibrosis. It was brought out in the evidence collected by the departmental committee on industrial diseases that china scourers and biscuit placers were probably the most liable to potters' asthma, but all the indoor occupations in the potteries are more or less affected, though, of course, to a considerably varying degree. A table was presented by Dr. Dawes of the deaths of potters in Longton, Staffordshire, for the period 1898 to 1906, showing conclusively the excessive incidence among potters of deaths from bronchitis, potters' asthma, and fibroid phthisis. All of these terms are more or less inclusive of each other.

COMPARATIVE OCCUPATIONAL MORTALITY STATISTICS.

A table was also introduced into the evidence by Dr. Tatham, based upon the mortality of England and Wales for 1900 to 1902, including comparative statistics for other dusty trades, as follows:

TABLE 96.—COMPARATIVE MORTALITY FROM PHTHISIS AND DISEASES OF THE RESPIRATORY SYSTEM IN CERTAIN SPECIFIED OCCUPATIONS, ENGLAND AND WALES, 1900 TO 1902.

Occupation.	Phthisis and diseases of the respiratory system.		Mortality figure.	
	Mortality figure.	Ratio.	Phthisis.	Diseases of respiratory system.
Agriculturist	161	100	79	82
Dock laborer, wharf laborer	632	393	291	341
Potter, earthenware, etc., manufacturing	741	460	277	464
Cutler, scissors maker	812	504	516	296
Tin miner	1,577	980	838	739
Nail, anchor chain, and other iron and steel manufactures	493	306	182	311
Stone, slate quarrier	390	242	186	204
Brass, bronze, manufacturer, founder, finisher, worker	469	291	262	207
Bricklayer, mason, builder	364	226	188	176

NOTE.—This table is to be read thus: Among a certain number of males aged 25 to 65 years in the general population, 1,000 deaths occurred during the years 1900 to 1902; of these 1,000 deaths, 186 were due to phthisis and 174 to diseases of the respiratory system. Among an equal number of agriculturists living, at the same ages, there were 79 deaths from phthisis and 82 from diseases of the respiratory system. Among an equal number of dock laborers, 291 and 341, respectively, and so on.

RESULTS OF SANITARY IMPROVEMENTS.

Attention was directed in the evidence to the material improvement in the health conditions of the pottery industry of England and Wales during the last 30 years, particularly by Dr. Frank Shufflebotham, who presented data relative to the frequency of fibrosis of the lungs as observed in the experience of the North Staffordshire Infirmary, Stoke-upon-Trent, which is a center of the English pottery industry. The seriousness of the existing situation, however, in 1907, when the departmental committee on industrial diseases made its investigations, is concisely set forth in a brief statement by Dr. C. Petgrave Johnson, as follows:

> I find that during the seven years, 1900-1906, of potters' pressers living in Stoke, 47 died. Of these, 14 died of bronchitis, 15 of phthisis, and 5 of pneumonia, i. e., over 72 per cent of the deaths were due to lung diseases. If the deaths in the North Stafford Infirmary and the Stoke-upon-Trent Union Hospital are included;

then 112 deaths among potters' pressers occurred in the same seven years. Of these 31 were due to bronchitis, 43 to phthisis, and 4 to pneumonia, i. e., 70 per cent of the deaths were due to lung diseases. These figures are correct.

I find that during the seven years, 1900–1906, in not a single instance in any of the deaths amongst potters' pressers occurring in the North Stafford Infirmary or in the workhouse hospital or in the borough of Stoke, is fibroid phthisis or potters' asthma, or cirrhosis of the lungs, or fibroid pneumonia given as the cause of death. Bronchitis, phthisis, pulmonary tuberculosis, pneumonia, are the diseases of the lungs which are mentioned.

I should like to supplement this by stating that the changes in the lungs caused by particles of dust progress very slowly, years passing during the development. Should tuberculosis of the lungs supervene, the man dies in a comparatively short time, and any lung changes due to dust do not attract attention. Should bronchitis develop, however, he survives for years, and latterly, in the intervals—if any—of comparative freedom from bronchitis, the lung changes due to dust may attract attention or may not. The bronchitis symptoms, however, always attract more attention.

INJURIOUSNESS OF SCOURING PROCESS.

These general observations concerning the pottery industry as a whole are amplified by an extensive amount of evidence concerning health-injurious processes in detail. Concerning china scouring, for illustration, it is said in the report of the chief inspector of factories and workshops for 1908, that—

"Scouring" is one of the many operations to which china is subjected during the course of its manufacture and is comparatively simple, being, in fact, merely subsidiary to the manufacturing process. In order to prevent the pieces of soft unbaked clay from becoming fused to each other, or to sides of the saggers in which they are placed during the firing in the kiln, each piece is separately buried in a bed of fine flint dust with which the sagger is filled. After the firing is accomplished this flint dust, which resembles fine sand, has to be removed. The heat causes a considerable portion of it to become fused to the surface of the baked ware to which it adheres, and it is therefore necessary to get rid of this by scrubbing each piece of ware with a dry and very stiff brush. The operation, as its name implies, is more drastic than that of mere dusting. The piece is first "knocked" and the sharp jars cause the loose dust to fall off, then scrubbed with a revolving motion with a stiff brush (often worked by power), and then it is rubbed with coarse flannel; finally, the remains of the rough adhering particles are smoothed off by means of sandpaper. From this description it will be seen that the operation is a very dusty one.

INJURIOUSNESS OF FLINT DUST.

Attention is directed in this statement to the difference between china scouring and earthenware "towing," it being stated that in earthenware the material to be removed is soft clay dust, while in china it is a very finely ground flint, the microscopical particles of which are sharp and jagged. The conditions are particularly unfavorable in small plants where rules and regulations regarding mechanical methods of dust removal can not be effectively applied except at prohibitive expense. At the same time it is thoroughly well recognized, and as pointed out in the report referred to, that "a microscopic examination of the flint in which china is bedded shows that owing to the shape of the particles it forms one of the most mechanically injurious of all dusts." And in the Staffordshire district the relation of this dust to pulmonary tuberculosis is so well known that death certificates frequently merely mention as cause of death the significant term "flint." Since most of this work is done by women, in the United States as well as in England and on the Continent, the mortality data, usually limited to males, have not become available. A special investigation, however, was made in the Longton district concerning the female population, with the result shown in Table 97.

TABLE 97.—MORTALITY FROM RESPIRATORY DISEASES (INCLUDING PHTHISIS) IN LONGTON: CHINA SCOURERS AND TOTAL FEMALE POPULATION COMPARED, 1896 TO 1898.

[Rates are based on female population in 1891 (10,561) and number of china scourers in 1898 (160), ages 15 to 70.]

Year.	Deaths from respiratory diseases (including phthisis) among—			
	All females.		China scourers.	
	Number.	Rate per 1,000 per annum.	Number.	Rate per 1,000 per annum.
1896	45	4.3	12	75.0
1897	49	4.6	11	68.9
1898[1]	29	5.5	6	75.0

[1] From January to June.

The data, of course, are of rather limited extent, but they are quite sufficient for the purpose of emphasizing the extreme injuriousness of china scouring as carried on under existing conditions which, as a general rule, preclude adequate consideration of effective methods for the control of the dust evil. As is well said in connection with the foregoing table in the report referred to—

> In order to reduce the appalling death rate shown in the table it is necessary to prevent the inhalation of flint by the workers. It is a fact that every form of dust produced during the course of a manufacturing process can be extracted from the workroom by means of a sufficient number of properly placed and efficiently contrived exhaust fans. The important point is that this should be done in such a manner as to prevent the dust from becoming dispersed in the air or from being drawn past the faces of the workers. In several factories we found that fans had been introduced, and when these were

efficient the atmosphere and the clothes of the women themselves were strikingly free from flint. In two factories we found substitutes for a fan, but we observed no difference between these and the places in which there were no means of removing the dust; in most cases the benches are placed directly in front of the windows, so that when these are open the dust is blown directly into the faces of the workers. The structural conditions of some of the smaller china factories are such that we are in agreement with the opinion of the medical members of the committee of 1893, and with that expressed in the special report of Profs. Thorpe and Oliver that "they are wholly or in part unfitted for use as work places, inasmuch as work can not be carried on in them without injury to health." In others, however, alterations entailing a small expense would very materially improve the conditions, while in all, so long as they are permitted to remain in use, effective means of drawing off the clouds of unhealthy dust are a necessity.

CONTINUOUSNESS OF INJURIOUS CONDITIONS.

This lamentable condition has remained practically unchanged in the pottery industry since its development on a large scale, for, as shown by the evidence before the royal commission of 1841,[1] inquiring into the employment of children and young persons, the excessive frequency of respiratory diseases resulting from exposure to flint and other dust was thoroughly well recognized at the time but considered inherent in the conditions under which the industry was carried on. Conditions in this country have not been subjected to an equally thoroughgoing scientific investigation, but the recorded observations of factory inspectors, health officials, and others quite fully confirm the prevailing view that while the health and mortality of potters in America are more favorable this is chiefly because of better sanitary surroundings, housing, food, etc., higher wages and shorter hours, and a decidedly lesser incidence of habits of intoxication. Dr. H. R. M. Landis, of the Phipps Institute of Philadelphia, in an investigation regarding American potteries points out that—

> His own observations had led him to believe that more care should be exercised on the part of the workmen in the disposal of the fragments of clay which were thrown off in the fashioning of the various utensils. Too much of it was allowed to fall on the floor about the work bench, and as a result was walked upon and quickly pulverized into dust. Face masks had been repeatedly advocated, but had never been particularly successful, for the reason that the workmen were averse to using them. He believed that these individuals, especially those working in the dusty departments, should be subjected to frequent medical inspections. A compulsory examination three or four times a year would undoubtedly result in detecting many cases which would otherwise pass into the terminal stages of potters' asthma or tuberculosis.[2]

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[1] Physical and Moral Condition of the Children and Young Persons Employed in Mines and Manufactures, London, 1843.

[2] Medical Record, July 25, 1914.

SANITARY ASPECTS OF THE POTTERY INDUSTRY IN OHIO.

Hayhurst in his numerous reports on industrial conditions in Ohio has extensively dealt with the pottery industry, and in a general way the results of his investigations confirm conclusions based upon foreign experience. Concerning slip making, which means the removing of the clays in the form of dust and lumps from the stock bins, followed by grinding, water washing, and sifting processes, through the use of pug mills, agitators, compressing machines, and drying kilns, the dust hazard was found to be serious in 23 work places, fairly serious in 6, and of small importance in 9, out of a total of 38. It was found that the chief causes of dust in the atmosphere in connection with slip making were the more or less constant shoveling of clays in the dry form, its escape from grinding machines, and its being raised from the floor by moving air currents, etc. In 20 of the places dampness was an additional occupational hazard, chiefly because of faulty floor drainage, leaky vats, etc. The general appearance of the workers was not more than fair in 30 of the 38 work places. Many prematurely aged, pale, and underweight men were seen among those longest employed. According to a report in the Ohio Public Health Journal for January-March, 1916, "the chief complaints of the workers were the breathing of dust, damp quarters, heat, fatigue, poor washing facilities, and general insanitary quarters." Excepting, however, the dust hazard, none of the other conditions was considered seriously injurious to health.

INJURIOUSNESS OF FLINT-DUST MAKING.

Flint-dust making without question is the most hazardous process in the pottery industry. Only a few of the large firms were found to employ this process on their own account, but the attention of the investigators was directed to two firms employing foreign laborers engaged in making this product, which involves crushing, grinding, conveying, and packing, in connection with all of which there was observed "an unusual amount of fine, hard flint dust, which pervaded the air of the work place and coated the openings of windows, doors, and roof vents with a white flourlike powder." It is, therefore, properly suggested that dust-confining machinery, short hours, and respirators are needed in all such places.

MOLD AND SAGGER MAKING.

In the same investigation the process of mold making was reported upon for 16 plants. The molds are made of plaster of Paris, which involves considerable exposure to a recognized injurious form of mineral dust. Health appliances to handle and confine the dust mechanically were found to be absent in all places. In 10 of the 16 places the dust was considered to constitute a fairly serious health hazard. In 10 of the work places the appearance of the workers was considered unsatisfactory. The chief complaint was on account of the breathing of the dust and general unsanitary features. It is suggested that it would appear "that mechanical means could be contrived to convey and weigh the dusts used, for being a dusty occupation and an injurious type of dust, workers should be under medical supervision, and, in addition, respirators should be furnished and worn during the performance of unavoidably dusty operations."

Sagger making is described by Hayhurst as consisting in the making, shaping, baking, finishing, and repairing of the clay containers in which the pottery ware is baked in the kilns. This occupation employs relatively few persons in the pottery industry. The dust factor was considered of importance in 10 out of 19 plants investigated. The chief cause of the dust was "the careless handling and dumping of clays and the disturbance of the dust on the floors and benches by the workmen or by air currents." The chief occupational hazard, however, was not the dust, but the liability to chronic lead poisoning. The general complaint was on account of the breathing of dust and exposure to dampness, with resulting liability to rheumatism. Heat exposure was not considered serious.

JIGGERMEN, JOLLYMEN, AND PRESSERS.

Pottery-making processes proper include the work of the throwers, the jiggermen, the jollymen, and the pressers. More precisely the employments in the Ohio pottery industry are stated by Hayhurst to include "batters-out, pressers, jiggermen, jollymen, turners, handlers, stickers-up, dish-specialty makers, finishers, machine pressers, mold boys (called also mold runners and dog trotters), and helpers." The processes in connection with these employments were investigated in 53 plants, including all branches of the industry, employing 3,048 wage earners, of whom 2,521, or 82.7 per cent, were males and 527, or 17.3 per cent, were females. The majority of all potters, it is stated, are employed in the bisque-making rooms. The class of workers was found to be mostly native and above the average. In 40 of the work places the employees were found to be exposed to a considerable hazard on account of the breathing of fine clay dust. Some machine pressrooms were free from dust, but others were very dirty, apparently because clays were handled drier. The finishers, chiefly women, who scrape rapidly revolving articles, ran the greatest dust hazard, while the mold boys and helpers, who handled the dried bisques in the ovens, suffered next in hazards. In no places were local exhaust systems found for the protection of finishers. Dampness was quite common and was found to be a serious hazard in 25 of the work places investigated. Complaint was made of insufficient heating, and poor ventilation was reported in more than half of the plants investigated, especially during the winter months. The basis of this complaint was the large number of work people assembled together, the presence of the baking ovens, and the lack of air agitators and air-conditioning systems, and often to the absence of ordinary vents in types of buildings which it was impossible to ventilate sufficiently without mechanical means. The general appearance of the workers was favorable in only 10 places, but in the balance many fatigued, under-weight, and physically inferior employees were observed. The usual complaints were on account of the heat, fatigue, dust, poor ventilation, dampness, and cold. It is held that this particular process is the chief source of tuberculosis in the pottery industry, and that many instances of the disease were brought to the attention of the investigators of the Ohio State Board of Health by both workmen and employers, usually, however, with the information that its occurrence was unavoidable. Among the hygienic shortcomings pointed out, the investigation emphasized the injurious nature of atmospheric changes and the absence of physical examination. Attention is directed to the fact that pneumonia is a frequent occupational disease among those who inhale clay and other mineral dust. The generally dust-contaminated nature of the atmosphere in the workrooms was sufficiently established to justify the conclusions arrived at.

Similar conclusions apply more or less to other processes in the pottery industry, the dangers of which in some cases, however, are materially increased by the risk of lead poisoning. How far there is a possible relation between lead poisoning and pulmonary tuberculosis has not been determined.[1] It is, however, fair to assume that whatever conditions result in a diminution of vital resistance generally must more or less act as a predisposing cause of pulmonary tuberculosis.

LEAD POISONING AND PULMONARY DISEASES.

The dangers of lead poisoning in the pottery industry have been reported upon in numerous official investigations, including Bulletin 104 of the United States Bureau of Labor Statistics. Dr. George Reid, in a discussion of the evidence of the departmental committee appointed to inquire into the dangers attendant on the use of lead in the manufacture of earthenware and china, published by the

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[1] Sir Thomas Oliver, in his "Lead Poisoning," London, 1914, pp. 83–88, carefully considers the question as to whether or not lead poisoning of itself predisposes to tuberculosis, including the opinion of Prof. Hahn of Munich and the animal experimentation of G. Loriga. Oliver concludes that "the only way in which it can do so is by reducing the general vital resistance of the individual."

British Government in 1910, raises, however, a very important question when, according to the British Medical Journal (Sept. 24, 1910), he remarks that, "without minimizing the gravity of the situation so far as lead poisoning is concerned, the mortality from this cause is a cipher compared with the deaths from phthisis and respiratory diseases—the death rate from plumbism per 1,000 being 0.81 compared with 7.05 for phthisis." In the same publication it is said that another interesting and far-reaching problem, which was also raised by Dr. Reid, was with reference to compensation in cases of lung diseases among potters, which is referred to as a problem bristling with difficulties. In proportion, of course, as industrial lung diseases are brought within the range of workmen's compensation for industrial injuries, as possibly quite separate and distinct from industrial diseases in the strictly limited sense of the term, the necessary methods and means of dust prevention will receive more adequate consideration.

The report of the departmental committee on the pottery trade is one of the most important contributions to the literature of occupational diseases, and although chiefly with reference to the dangers of lead poisoning, the report includes a mass of related evidence of exceptional usefulness in general consideration of the health problem in industry. The investigation of the special committee included 550 pottery works employing 63,000 persons and 7 lithographic transfer works. It was found that out of 63,000 workers 6,856, or 11 per cent, were brought in contact with lead, whereas 23,000, or 37 per cent, were exposed to the inhalation of dust. The latter conclusion, however, must be accepted in a restricted sense, since the committee apparently concerned itself only with dust obviously seriously injurious and sufficiently determinable as to quantity and health-injurious qualities. It is difficult to accept the conclusion that 53 per cent of the workers in English potteries, as stated in a letter in the Journal of the American Medical Association, dated London, July 9, 1910, "are not exposed to any particular danger to health." Investigations in this country, particularly in Ohio, indicate that a much smaller proportion of pottery employees is engaged in relatively harmless employments.

MORTALITY OF POTTERS—UNITED STATES REGISTRATION AREA.

The mortality of potters has been reported upon only for the year 1909 by the Division of Vital Statistics of the United States Census Bureau and no subsequent information has been made public, so that the data are of rather limited value. This is particularly regrettable in the case of so important an occupation as the pottery industry, for the mortality returns for the United States registration area for the year referred to are limited to 136 deaths from all causes, of which 47, or 34.6 per cent, were from pulmonary tuberculosis. The details of the mortality by divisional periods of life are shown in Table 98.

TABLE 98.—PROPORTIONATE MORTALITY OF POTTERS FROM PULMONARY TUBERCULOSIS, UNITED STATES REGISTRATION AREA, 1909, BY AGE GROUPS.

Age at death.	Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent of deaths from all causes.
15 to 24 years	13	6	46.2
25 to 34 years	27	12	44.4
35 to 44 years	26	11	42.3
45 to 54 years	32	12	37.5
55 to 64 years	12	5	41.7
65 years and over	26	1	3.8
Total, 15 years and over	136	47	34.6

TABLE 99.—PROPORTIONATE MORTALITY OF POTTERS FROM NONTUBERCULOUS RESPIRATORY DISEASES, UNITED STATES REGISTRATION AREA, 1909.

Cause of death.	Deaths from nontuberculous respiratory diseases.	
	Number.	Per cent of deaths from all causes.
Asthma	1	0.7
Bronchitis	1	.7
Pneumonia	9	6.7
Other nontuberculous respiratory diseases	6	4.4
Total	17	12.5

Table 98, although limited to a relatively small number of deaths, quite conclusively sustains the results of other investigations as regards the excessive frequency of pulmonary tuberculosis in the pottery industry throughout practically the entire working period of life. Aside from the distinctly excessive proportion of deaths from pulmonary tuberculosis the mortality from nontuberculous respiratory diseases, shown in Table 99, is also excessive, or 12.5 per cent, compared with 9.2 per cent for glassworkers and 10 per cent for all occupied males, according to data received from the same official American sources.

MORTALITY OF POTTERY EMPLOYEES—MEDICO-ACTUARIAL EXPERIENCE.

The only really conclusive statistics regarding the mortality of potters in the United States are derived from life insurance experience. As a general rule both life insurance companies and fraternal societies are extremely cautious in accepting risks on the lives of persons employed in at least the more health-injurious processes of the pottery industry. Dippers, flint-mill workers, ground layers, mixers, scourers, and sweepers are generally declined, unconditionally. Kilnmen, mold makers, placers, pug-mill workers, sagger makers, and slip makers are occasionally accepted, but at somewhat higher premium rates than those charged men in recognized healthy employments. Most of the risks accepted in the pottery industry include decorators, fillers-in, jiggermen, jollymen, pressers, printers, throwers, and warehousemen. These observations require consideration in view of the results of the medico-actuarial investigation concerning pottery employees, chiefly molders, excluding foremen and superintendents.

TABLE 100.—MORTALITY FROM ALL CAUSES AMONG POTTERY EMPLOYEES (CHIEFLY MOLDERS, EXCLUDING FOREMEN AND SUPERINTENDENTS) BY AGE GROUPS.

[Medico-Actuarial Investigation.]

Age at death.	Number exposed to risk one year.	Actual deaths.	Expected deaths.	Ratio of actual to expected deaths.
15 to 29 years	1,194	13	5.44	239
30 to 39 years	999	9	5.93	152
40 to 49 years	391	4	3.68	109
50 to 59 years	45	1	.66	152
60 years and over	16	1	.74	135
Total	2,645	28	16.45	170

It is shown in Table 100 that the general mortality of pottery employees, subject to the preceding qualifications, is 70 per cent in excess of the expected. The small number of risks under observation precludes final conclusions, but the data are decidedly suggestive of distinctly health-injurious conditions inherent in the American pottery industry, even after excluding the recognized unhealthy branches of the trade. In industrial insurance no such discriminations prevail, all employments being accepted. Unfortunately, in the mortality returns the death certificates frequently fail to state the precise occupation, and on account of the peculiar nomenclature common to the pottery industry there is a considerable degree of confusion. Thus decorators, pressers, printers, warehousemen, sweepers, etc., may be returned under entirely different occupational terms unless it is specifically stated that the employment was in connection with the pottery industry.

MORTALITY OF POTTERS—INDUSTRIAL INSURANCE EXPERIENCE.

In Table 101, derived from the industrial insurance experience of the Prudential Insurance Co. of America, the term "potters" is limited to only such deaths as were clearly of persons connected with the pottery industry, which, in part, explains the rather limited mortality under observation. The table includes 801 deaths of potters from all causes, of which 258, or 32.2 per cent, were from pulmonary tuberculosis.

TABLE 101.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG POTTERS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, COMPARED WITH THAT OF ALL MALES IN UNITED STATES REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of potters, 1897 to 1914, from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Potters.	Males in registration area, 1900 to 1913.
15 to 24 years	77	24	31.2	27.0
25 to 34 years	137	68	49.6	30.5
35 to 44 years	181	72	39.8	23.4
45 to 54 years	172	52	30.2	14.7
55 to 64 years	147	31	21.1	7.9
65 years and over	87	11	12.6	2.6
Total, 15 years and over	801	258	32.2	13.9

The table exhibits an excessive frequency of pulmonary tuberculosis at all ages; in fact, an extremely high proportion is maintained throughout the older ages when in the general experience other diseases tend to predominate. The experience confirms the preceding observations and conclusions derived from American and foreign experience, that the pottery industry in general, and among many of the more specialized processes in particular, must be considered seriously injurious to health and life, and for the reasons stated the requirement of thoroughgoing sanitary rules and regulations is self-evident. While there has been some progress in the direction of improved methods of factory supervision in this country with special reference to the pottery industry, we are as yet far from having attained to the more well-considered governmental practices of European countries.

FOREIGN SANITARY REGULATIONS OF THE POTTERY INDUSTRY.

Attention may be directed in this connection to the regulations adopted under date of January 2, 1913, by the British Government with special reference to the manufacture and decoration of pottery, reprinted in a special bulletin of the New York Department of Labor.[1] The particular regulations concerning the suppression of dust, the use of respirators, and ventilation are as follows:

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[1] European Regulations for Prevention of Occupational Diseases. Special Bulletin No. 76, published by the New York State Industrial Commission, Albany, March, 1916.

Regulations for the Suppression of Dust.

(*a*) The following processes shall not be carried on without the use of an efficient exhaust draft:

(i) The fettling of flat ware, whether china or earthenware, by towing or sandpapering, provided that this shall not apply to the occasional finishing of pieces of china or earthenware without the aid of mechanical power;

(ii) The sand-sticking of sanitary ware;

(iii) Any other process of fettling on a wheel driven by mechanical power, except where:

(*a*) The fettler is fettling, as an occasional operation, only ware of his or her own making; or

(*b*) The fettling is done wholly with a wet sponge or other moist material; or

(*c*) The fettling is done by the worker who has made the articles, whilst the latter are still in a moist state.

(iv) The sifting of clay dust for making tiles or other articles by pressure, except where:

(*a*) This is done in a machine so inclosed as effectually to prevent the escape of dust; or

(*b*) The material to be sifted is so damp that no dust can be given off.

(v) The pressing of tiles from clay dust; an exhaust opening being connected with each press; this clause shall also apply to the pressing from clay dust of articles other than tiles, unless the material is so damp that no dust is given off.

(vi) The fettling of tiles made from clay dust by pressure, except where the fettling is done wholly on or with damp material; this clause shall also apply to the fettling of other articles made from clay dust, unless the material is so damp that no dust is given off.

(vii) The processes of bedding and flinting.

(viii) The brushing of earthenware biscuit, unless the process is carried on in a room provided with efficient general mechanical ventilation or other ventilation which is certified by the inspector of factories for the district as adequate, having regard to all the circumstances of the case.

(ix) Scouring of biscuit ware which has been fired in powdered flint, except where this is done in machines so inclosed as effectively to prevent the escape of dust.

(x) Batting of biscuit ware which has been fired in powdered flint.

(xi) Glaze blowing.

(xii) Ware cleaning after the application of glaze by dipping or other process, except as set forth later in this regulation.

(xiii) The preparation or weighing out of flow material which yields to dilute hydrochloric acid more than 5 per cent of its dry weight of a soluble lead compound calculated as lead monoxide when determined in the manner described in the definition of low solubility glaze.

(xiv) The lawning of dry colors, except where not more than an ounce at a time is lawned for use in painting.

(xv) Ground laying, including the wiping off of color after its application to the surface of the ware.

(xvi) Color dusting, whether underglaze or on-glaze, including the wiping off of color after its application to the surface of the ware.

(xvii) Color blowing or aerographing, whether underglaze or on-glaze, including the wiping off of color after its application to the surface of the ware.

(xviii) The making of lithographic transfers, including the wiping off of color after its application to the surface of the transfer sheets.

(*b*) In the process of mold making, every bin or similar receptacle used for holding plaster of Paris shall be provided with an efficient exhaust draft so arranged as to prevent the escape of plaster of Paris dust into the air of the work place, except where a cover is provided for the bin or other receptacle and the plaster of Paris is conveyed in a sack, the mouth of which is tied and only loosened after it has been placed in the bin or other receptacle.

(*c*) The dry grinding of materials for pottery bodies shall be done either with an efficient exhaust draft for the removal of dust, or in machines so inclosed as effectually to prevent the escape of dust; except that it shall not be deemed necessary in pursuance of this regulation to provide an exhaust draft to remove small amounts of dust given off at the hopper of an inclosed machine in the course of feeding the same, if an outlet into an exhaust duct or to the outside air is fitted to the receptacle into which the powdered material is delivered.

(*d*) In the process of sand sticking of sanitary ware, suitable provision shall be made for collecting any material which falls on the floor.

(*e*) In the process of making tiles from clay dust by pressure, supplies of material shall be conveyed to the workbenches in such a manner as to disperse as little dust as possible into the air; clay dust shall not be carried into any press shop in sacks except where hoppers or similar receptacles are provided for receiving the clay dust, in which case a sack in sound repair shall be used and the mouth of the sack shall be tied and only loosened after it has been placed in the hopper or other receptacle, which shall be provided with a cover. This clause shall also apply to the making from clay dust of articles other than tiles, unless the material is so damp that no dust is given off.

(*f*) After one year from the date on which these regulations come into force, biscuit flat ware which has been bedded for firing shall not be removed from the saggers after firing, except at a bench fitted with an efficient exhaust appliance for the removal of dust.

(*g*) Flat knocking and fired-flint shifting shall be carried on only in inclosed receptacles, which shall be connected with an efficient exhaust draft, unless so contrived as to prevent effectually the escape of dust.

(*h*) In the process of ware cleaning of earthenware after the application of glaze by dipping or other process, wherever it is practicable to use damp sponges or other damp materials they shall be provided in addition to the knife or other instrument, and shall be used.

(*k*) Nothing in these regulations shall render it compulsory to provide an exhaust draft for ware cleaning if this process is carried on entirely with the use of wet materials; or if the ware cleaning be done within 15 minutes after the moment when the glaze was applied; but an efficient exhaust draft shall always be provided and used if any dry materials or implements, such as knives or scrapers, are used after the glaze is dry or more than 15 minutes after the moment when the glaze was applied.

(*l*) In the process of ware cleaning, after the application of glaze by dipping or other process, sufficient arrangements shall be made for any glaze scraped off, which is not removed by the exhaust draft, to fall into water. All water troughs or other receptacles provided in pursuance of this clause shall be cleaned out and supplied with fresh water as often as necessary, and in no case less often than once a week; and no scrapings of glaze shall be allowed to collect in a dry condition on the sides of the water receptacle. Where grids or gratings are fitted over the water trough or other receptacle named in the foregoing paragraph, they shall be kept clean by repeated sponging or wiping with wet material during the time that the process of ware cleaning is being carried on. No boards or other articles shall be placed, even temporarily, on any such water trough, in such a way as to interfere with the efficient use of the trough.

(*m*) In all processes the occupier shall, as far as practicable, adopt efficient measures for the removal of dust and for the prevention of any injurious effects arising therefrom.

(*n*) Every process for which an exhaust draft is prescribed shall be carried on inside a hood or exhaust funnel, provided that where the occupier can show that this is impracticable it shall be sufficient if the work is done within the effective range of an exhaust opening.

RESPIRATORS.

(*a*) No person shall be allowed to work without wearing a suitable and efficient respirator, such as a damp sponge tied across the mouth and nostrils, in any of the following processes:

(i) The emptying of sacks of plaster of Paris into a bin in a mold-making shop.

(ii) The weighing out, shoveling, or mixing of unfritted lead compounds in the preparation or manufacture of frits, glazes, or colors containing lead, or any process carried on in a room wherein any such weighing out, shoveling, or mixing has taken place within the previous 30 minutes.

unless an efficient exhaust draft is provided to prevent the escape of dust into the air of the work place.

(*b*) All respirators required by this regulation shall be provided and maintained in a cleanly state by the occupier, and each respirator shall bear the distinguishing mark of the worker to whom it is supplied.

VENTILATION.

(*a*) Every place in which any worker or workers are employed shall be thoroughly ventilated.

(*b*) All workrooms in which articles are left to dry shall be ventilated in such a way as to insure a continuous movement of the air in the room in a direction away from the workers and toward the articles in question.

(*c*) All drying stoves shall be ventilated direct to the outside air by shafts having upward inclinations and terminating vertically or by louvers in the roof or by other effective means.

(*d*) All mangles shall be so ventilated as to provide for the maintenance of a flow of air into the hot chamber from the adjoining workroom.

In the case of vertical or "tower" mangles:

(i) The pipes for heating the mangle shall be fixed above the top of any opening at which workers put in or take off ware; and

(ii) There shall be a free outlet into the air above so formed and placed as to insure an outflow whatever the direction of the wind.

(*e*) Fresh air shall, where practicable, be admitted to all workrooms by inlets placed along the sides of the room at a height of as nearly as possible

6 feet above the floor level, hopper opening being used for the purpose wherever possible.

(*f*) Where it is not practicable to provide such fresh air inlets arrangements shall be made for the entry of an adequate amount of pure air by a flue with apertures at intervals along its length or other means, which will secure an even distribution of the air through the room.

(*g*) In no case shall fresh-air inlets be so arranged that a draft can blow direct from them onto any worker.

(*h*) Wherever the natural air currents are found to be insufficient without assistance to afford thorough ventilation, exhaust fans, or other artificial means of creating a current of air shall be provided and maintained in use.

(*k*) Where an exhaust draft is provided for the removal of dust generated in a manufacturing process precautions shall be taken to prevent dust being drawn into the general atmosphere of the room from other sources of dust in places in the vicinity; communication with such places shall be stopped wherever possible, and the fresh-air inlets hereinbefore mentioned shall be so arranged as to insure that no extraneous dust is drawn toward the workers by the exhaust draft.

GENERAL CONCLUSIONS.

These rules and regulations are an admirable illustration of really effective methods by which the intrinsic health-injurious factors in a given industry can be reduced to a practically attainable minimum. The conclusions, while specifically applicable to the pottery industry, are equally suggestive of a far-reaching reduction of occupational hazards in other dusty trades.

PAINT AND COLOR WORKERS.

The dust hazard in paint and color manufacture is chiefly of a mineral nature, but the use of metallic substances frequently includes industrial poisons which it must be assumed tend to increase the resulting hazard to health and life. Antimony, arsenic, chromium, lead, manganese, mercury, zinc, etc., are the usual ingredients of paints and colors used extensively in the industries and arts. Mineral paints are divided into three groups—(1) natural mineral pigments, (2) pigments made directly from ores, and (3) chemically manufactured pigments, all of which during ordinary processes of manufacture expose the workmen to a considerable amount of dust. Many minerals or mineral products, it is stated in the annual report of the United States Geological Survey for 1914, by James M. Hill, "are used in the paint trade, such as asbestos and products derived from it, aluminium, asphalt, barytes, clay, graphite, gypsum, magnesite, mica, pyrite, quicksilver, shells, silica, talc, tripoli, and many by-products."

CHEMICAL ASPECTS OF PAINT MANUFACTURE.

How far these wide variations in the basic nature of the materials used affect health and life with special reference to pulmonary tuberculosis is at the present time not even a matter of scientific conjecture. The natural mineral pigments which constitute an important group, comprise, according to the same authority, "ocher, umber, sienna, ground slate and shale, metallic paint, and mortar colors." The three ores of iron, hematite, siderite, and limonite, are the basic constituents of metallic paints which enter to a considerable extent into numerous processes of manufacture directly or indirectly, as the case may be. Pigments made directly from ores, it is stated, comprise zinc oxide, leaded zinc oxide, sublimated white lead, and sublimated blue lead.[1] In the chemically manufactured pigments basic carbonate white lead, litharge, red lead, orange mineral, lithophone, and Venetian red are extensively used. The importance of the mineral paint industry is best illustrated by the statement that during 1914 the United States product was valued at nearly $40,000,000.

EXPOSURE TO METALLIC DUST.

The amount of metallic dust in paint manufacture would be relatively unimportant were it not for the frequently poisonous nature of the substances used. As observed by W. Gilman Thompson with reference to white lead, the material is first dried, then pulverized, and diluted with oil and pigment, in connection with which processes the dust hazard is quite important, while there exists the additional risk of an increased susceptibility to pulmonary tuberculosis. Painters, in connection with the use of paints, are probably exposed to a lesser liability to dust inhalation than is common to dry-color grinding and related processes, but it is quite possible that the risk of lead poisoning is more serious.

HYGIENE OF THE PAINTERS' TRADE.

The hygiene of the painters' trade has been reported upon with admirable completeness, but with special reference to industrial poisoning, by Alice Hamilton, M. D., in Bulletin 120 of the United States Bureau of Labor Statistics. The importance of dust as a cause of lead poisoning is emphasized by Dr. Hamilton, it being stated that British experiments show that lead enters the bronchial tubes and lungs and even penetrates the capillaries, thus reaching the blood stream. She refers to German authorities as holding that "if any lead is absorbed through the respiratory tract, it must be small in amount, and while it is true that the breathing of lead dust causes poisoning, this is not because the lead reaches the bronchial tubes, but because it is caught in the mouth and throat, mixed with the saliva, and swallowed." Lehmann, a German authority, is quoted to the effect that "the great bulk of the inhaled dust finds its way into the stomach and not into the lungs." It is said that the dust lodges on the nasal and pharyngeal mucous membrane, and that the dust-laden secretions are then swallowed. It is estimated that at most less than one-fourth of the dust reaches the lungs. Soluble dusts are easily absorbed, and the conclusion is advanced that, irrespective of the theory accepted, "there is no question that poisoning takes place more rapidly the dustier the occupation, and therefore those parts of the painters' trade that are accompanied by dust production are the most dangerous."

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[1] Lead and Zinc Pigments, by Clifford Dyer Holley, M. S., Ph. D., New York, 1909.

These observations bear directly upon the broader question of increased liability to pulmonary tuberculosis in consequence of metallic or mineral dust inhalation. The serious importance of lead poisoning in paint manufacture and the painters' trade probably account for the very limited consideration which has been given to the equally important question of a possibly enhanced liability to pulmonary tuberculosis.

SANITARY CONDITIONS IN THE GERMAN PAINT INDUSTRY.

The most important investigation into the health of persons employed in the manufacture of paint was published in 1893 through the cooperation of the color manufacturers, Meister, Lucius & Brüning, of Höchst a. M., and Dr. Grandhomme, who thoroughly examined into the sickness experience for the preceding decade and whose observations include the results of a study of factory conditions, raw materials, and the processes of manufacture in detail, but with special reference to the analine-dye industry.[1] On account of the excellence of hygienic precautions and the emphasis placed upon the personal hygiene of the workmen, the observed experience is probably not conclusive with regard to paint and color factories in the United States. The amount of sickness was relatively high and apparently on the increase, but the average duration of the sickness was comparatively favorable, having varied between 5 and 9 days per case and between 4.1 and 8.4 days per workman per annum. The medical results of the investigation are too involved to permit of a brief analysis, but with special reference to pulmonary tuberculosis it may be said that the number of cases observed was apparently not excessive. Of the entire morbidity, including 18,723 cases of sickness, 2,762, or 14.7 per cent, were attributed to diseases of the respiratory organs, including pulmonary tuberculosis. The mortality from all causes during the period 1883–1892 was 7 per 1,000, which can not be considered excessive, although the proportion of young persons employed was probably relatively high. Out of 126 deaths from all causes, 55 were from pulmonary tuberculosis, 11 from pneumonia, and 12 from other respiratory diseases. An excessive amount of mortality from tuberculosis and other respiratory diseases is, therefore, conclusively brought out by the mortality analysis, although apparently in contradiction to the morbidity experience. This is in part explained by the relative frequency of digestive disorders and general nutritional disturbances, as well as affections of the skin. Aside from the considerable number of cases of industrial injuries, as far as the experience permits of a definite conclusion, it would appear that the mortality from pulmonary tuberculosis in the German paint and color industry, even under a well-considered plan of hygienic supervision is unduly high, and that it is safe to assume that the excess in the incidence of the disease is directly attributable to the more or less considerable risk of continuous inhalation of metallic and mineral dust, increased in the severity of its effects by the presence of poisonous substances, generally arsenic and lead.

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[1] Die Fabriken der Aktien-Gesellschaft Farbwerke vorm. Meister, Lucius & Brüning zu Höchst a. M., Frankfurt a. M., 1893.

LIABILITY TO METALLIC POISONING.

The paint industry was inquired into by the New York State Factory Investigating Commission. In the report for 1913 (vol. 2, p. 1152) it is said that six factories were inspected and that three used arsenic colors, but to a limited extent, the principal output being lead colors. No cases of poisoning were found among the workers, and the information secured was, therefore, negative. It is stated, however, "That there is danger can not be doubted, for the reports of other countries and the report of one case to the department of labor demonstrate the fact. The process wherein the danger lies is from the dust created in handling the dry arsenic color. In this industry there is danger of mixed poisoning." Other observations on the part of the commission have reference to the risk of lead poisoning, but there is an extended description of a plant engaged in the manufacture of arsenic color with regard to which it is said that the special process of mixing the materials is "very dusty." No provision was made for keeping down the dust or exhausting it. It is interesting to note that one worker was examined who said he had been employed for 32 years, but who showed no symptoms and gave no history of ever having had arsenic poisoning. The irritant action of arsenic dust was fully demonstrated by experimental inquiry, and the conclusion is advanced that the chief danger from the dust is in the processes of drying, bolting, and packing. No direct relation between arsenic dust inhalation and a predisposition to pulmonary tuberculosis was shown to exist by the investigation referred to.

MORTALITY OF PAINTERS, GLAZIERS, AND VARNISHERS.

The mortality of painters, glaziers, and varnishers considered as a group has been reported upon for the years 1908 and 1909 by the Division of Vital Statistics of the United States Census Bureau. The group, unfortunately, is so very large and inclusive of so many widely different specific employments or occupational conditions that the results of the analysis must be accepted with reserve. Proportionately, of course, painters predominate in the group under consideration and it is a safe assumption that the other occupations do not very materially modify the proportionate mortality figure from pulmonary tuberculosis. Thoroughly specialized investigations, however, regarding particular employments (for, of course, even the term "painter" covers quite a group of more or less varying occupations) might and probably would disclose important differences in the specific liability to pulmonary tuberculosis, particularly with reference to exposure to health-injurious minerals and metallic dust. Among painters, naturally, the liability to lead poisoning is a special occupational danger, but the actual mortality from lead poisoning is proportionally so small, at least among American painters, that the relative effect of the same can not be considered of material importance. According to the census report, out of 7,294 deaths of painters, glaziers, and varnishers from all causes, 1,361, or 18.7 per cent, were from pulmonary tuberculosis. The details of the mortality by divisional periods of life are shown in Table 102.

TABLE 102.—PROPORTIONATE MORTALITY OF PAINTERS, GLAZIERS, AND VARNISHERS FROM PULMONARY TUBERCULOSIS, UNITED STATES REGISTRATION AREA, 1908 AND 1909, BY AGE GROUPS.

Age at death.	Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent of deaths from all causes.
15 to 24 years	429	132	30.8
25 to 34 years	968	357	36.9
35 to 44 years	1,423	415	29.2
45 to 54 years	1,598	278	17.4
55 to 64 years	1,474	132	9.0
65 years and over	1,398	46	3.3
Age unknown	4	1	25.0
Total, 15 years and over	7,294	1,361	18.7

TABLE 103.—PROPORTIONATE MORTALITY OF PAINTERS, GLAZIERS, AND VARNISHERS FROM NONTUBERCULOUS RESPIRATORY DISEASES, UNITED STATES REGISTRATION AREA, 1908 AND 1909.

Cause of death.	Deaths from nontuberculous respiratory diseases.	
	Number.	Per cent of deaths from all causes.
Asthma	11	0.2
Bronchitis	47	.6
Pneumonia	533	7.3
Other nontuberculous respiratory diseases	64	.9
Total	655	9.0

COMPARATIVE MORTALITY OF PAINTERS, GLAZIERS, VARNISHERS, AND AGRICULTURAL LABORERS.

The proportionate mortality from pulmonary tuberculosis among painters, glaziers, and varnishers considered as a group was above the average for all occupied males throughout the entire working lifetime, but the excess does not assume serious proportions, which, however, does not preclude the conclusion that more selected groups of occupations in the entire group of allied employments under consideration would show a much more decided liability to pulmonary tuberculosis than is shown to be the case for the employment considered in the aggregate. In a general way, however, the mortality of painters, glaziers, and varnishers from pulmonary tuberculosis conforms to the general average for all occupied males, but it is decidedly above the average when comparison is made with agricultural employments, as is shown in Table 104.

TABLE 104.—COMPARATIVE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG PAINTERS, GLAZIERS, AND VARNISHERS, AND FARMERS, PLANTERS, AND FARM LABORERS, UNITED STATES REGISTRATION AREA, 1908 AND 1909, BY AGE GROUPS.

Age at death.	Per cent of deaths from all causes due to pulmonary tuberculosis.	
	Agricultural employments.	Painters, etc.
15 to 24 years	23.5	30.8
25 to 34 years	26.2	36.9
35 to 44 years	19.1	29.2
45 to 54 years	12.1	17.4
55 to 64 years	6.7	9.0
65 years and over	2.4	3.3
Age unknown	7.9	25.0
Total, 15 years and over	8.7	18.7

The preceding comparison is especially suggestive in that it emphasizes the inherent limitations of a mortality comparison in which all occupations are considered the standard. For the present purpose it has seemed advisable to compare painters, who, of course, numerically constitute an exceptionally important group of occupations, with employments typical of outdoor labor carried on under the most wholesome conditions as regards physical activity, air, relative freedom from dust exposure, etc. The comparison, throughout, is distinctly in favor of agricultural employments, and emphasizes the more or less health-injurious conditions under which painters, glaziers, and varnishers, considered as a group, are employed throughout practically the entire working period of life. How far the relatively high mortality from pulmonary tuberculosis as determined by this comparison is attributable to the special risk of lead poisoning can not be determined at the present time; but it is a safe conclusion that there is some such relation, although the recorded mortality from lead poisoning among American painters is comparatively low; in other words, it is rather because of complications resulting from gradual lead absorption as a factor in other diseases, including pulmonary tuberculosis, than as a direct cause of death that lead poisoning assumes importance in occupational or industrial hygiene. Aside from the relatively high proportion of deaths from pulmonary tuberculosis the mortality from nontuberculous respiratory diseases among painters, glaziers, and varnishers in comparison with farmers, planters, and farm laborers is not excessive. For painters, etc., considered as a group the proportionate mortality from all nontuberculous respiratory diseases is 9 per cent, which compares with 9.3 per cent for farm laborers. The proportions for asthma, pneumonia, and other respiratory diseases are about the same, but for bronchitis the mortality figure for agricultural workers is exactly twice the average for painters, considered as a group, or 1.2 per cent against 0.6 per cent. These conclusions, however, must not be carried too far, in view of the fact that two groups are compared which include quite a number of employments with a more or less varying degree of exposure to conditions unfavorable to health and longevity.

MORTALITY OF PAINT MIXERS—INDUSTRIAL INSURANCE EXPERIENCE.

There are no conclusive vital statistics of men employed in the American mineral paint industry, whether considered as a group or according to its several more important subdivisions. In the experience of the Prudential Co. (1897–1914) 36 deaths from all causes in paint factories, excepting mixers, occurred, of which 6, or 16.7 per cent, were from pulmonary tuberculosis. The experience is, of course, too limited to be conclusive. Among paint mixers, separately considered, however, there were 88 deaths from all causes, of which 21, or 23.9 per cent, were from pulmonary tuberculosis. This experience is given in detail in Table 105.

TABLE 105.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG PAINT MIXERS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, COMPARED WITH THAT OF ALL MALES IN UNITED STATES REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of paint mixers, 1897 to 1914, from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Paint mixers.	Males in registration area, 1900 to 1913.
15 to 24 years	6	4	66.7	27.0
25 to 34 years	17	5	29.4	30.5
35 to 44 years	16	5	31.3	23.4
45 to 54 years	27	7	25.9	14.7
55 to 64 years	13	....	....	7.9
65 years and over	9	....	....	2.6
Total, 15 years and over	88	21	23.9	13.9

The statistics, though unfortunately too limited for entirely safe conclusions, may be accepted as a sufficiently trustworthy indication that paint mixers are unquestionably liable to an excessive mortality from pulmonary tuberculosis, which in all probability upon further inquiry will be found to correspond proportionately to the nature and the quantity of the dust inhaled in the mixing processes. Even in the case of men employed in paint factories, excluding mixers, the experience is fairly suggestive of unfavorable conditions, though obviously much less so than those known to exist in the mixing processes separately considered. When the data for paint factories are made to include mixers, the experience is represented by 124 deaths from all causes, of which 27, or 21.8 per cent, were from pulmonary tuberculosis. At ages 35 to 44, out of 25 deaths, 10, or 40 per cent, were caused by pulmonary tuberculosis, which, of course, is decidedly excessive.

GENERAL CONCLUSIONS.

In the absence of more definite and trustworthy data, the foregoing brief observations concerning an important and rapidly intending industry are suggestive of the urgency of better sanitary conditions, chiefly the use of practical methods of dust prevention, both by more adequate dust-removing processes at the point of origin and the use of respirators in processes where the control of the dust danger must necessarily be one of exceptional difficulty.

LITHOGRAPHERS.

Lithographers constitute an important branch of the printing trade. According to the census of 1910 there were some 8,138 lithographers in the United States, of which number 477 were females. For hygienic reasons the employment of the lithographer should be considered separately from printing and engraving, since the former is exposed chiefly to mineral dust, while the latter are exposed primarily to the inhalation of metallic dust. Lithographic stone has been defined as a fine, compact homogeneous limestone, practically all of which is (or was) imported from Germany. The small amount of lithographic stone quarried in the United States varies in its mineral and metallic constituents from the Bavarian stone, containing nearly 7 per cent of magnesia. No accurate observations have been made a matter of record to determine the degree of possible lung injury resulting in the case of the lithographer's occupation, but it is safe to assume that the employment should be included in the group of dusty trades. This conclusion is fully sustained by a knowledge of the technical processes which constitute the lithographic art.

The sanitary conditions of this employment received consideration by Sir John Simon in his report as medical officer of the Privy Council. Simon called attention to the dust resulting from the use of colors and pigments, against the inhalation of which only very few of the workmen had adopted intelligent precautions. The most pernicious of the mineral or metallic colors employed in connection with lithography were emerald green and bronze. Simon did not connect the inhalation of this dust with the occurrence of phthisis, but the inference would seem warranted that such a connection exists, at least in exceptional cases.[1]

Parry, in his "Risks and Dangers of Various Occupations," confirms the earlier opinion, and holds that in lithographing green arsenical pigments are used, the poisonous dust of which is inhaled and conveyed to the stomach. It is evident that the poisonous character of the colors or pigments is a more serious factor than the dust of the stone itself, but how far either form of dust increases the liability to tuberculosis has not been determined.

MORTALITY OF ENGLISH LITHOGRAPHERS.

The most recent English mortality statistics of lithographers are for the three years ending with 1902, referred to in the Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales (p. lix), in part as follows:

At all ages except 20 to 25 and 45 to 55 the death rates among these workers exceed the standard for all occupied and retired males. These workers experience a lower mortality than printers up to the age of 45, but beyond that age the mortality in the two occupations differs but slightly. In the main working period of life the comparative mortality figure of lithographers is 964, or 4 per cent, below the average. Their mortality from influenza and phthisis considerably exceeds the standard, while that from respiratory diseases is below it by about an equal amount.

The English mortality statistics for lithographers are rather inconclusive as to a decidedly unfavorable effect of this industry on health, and while in Table 106 a comparison is made of the mortality from all causes of men in this group with occupied males generally, the death rates are, as a rule, below the average for occupied males generally except at ages 20 to 24 and 45 to 54, inclusive.

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[1] Report of the medical officer of the Privy Council for 1860, pp. 30 et seq. and 102 et seq.; for 1861, pp. 11 et seq. and 138 et seq.; for 1862, pp. 10 et seq. and 126 et seq.; and for 1863, pp. 29 to 31.

TABLE 106.—MORTALITY FROM ALL CAUSES OF LITHOGRAPHERS, COMPARED WITH THAT OF ALL OCCUPIED MALES, IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[Source: Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 for all occupied males.	Death rate for lithographers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	2.44	1.55	−0.89	64
20 to 24 years	4.41	5.36	+ .95	122
25 to 34 years	6.01	5.62	− .39	94
35 to 44 years	10.22	8.41	−1.81	82
45 to 54 years	17.73	19.94	+2.21	112
55 to 64 years	31.01	30.84	− .17	99
65 years and over	88.39	82.25	−6.14	93

The preceding table is self explanatory, but a more extended comparison is made in Table 107, in which the mortality of lithographers from pulmonary tuberculosis is compared with the normal mortality of occupied males from this disease, by divisional periods of life. This table shows that the mortality of lithographers from tuberculosis is above the average at all ages by from 0.23 to 2.17 per 1,000. The excess is not very marked and does not warrant decidedly unfavorable conclusions.

TABLE 107.—MORTALITY FROM PULMONARY TUBERCULOSIS AMONG LITHOGRAPHERS, COMPARED WITH THAT OF ALL OCCUPIED MALES, IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[Source: Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Mortality from pulmonary tuberculosis.			
	Death rate per 1,000 for all occupied males.	Death rate for lithographers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	0.54	0.77	+0.23	143
20 to 24 years	1.55	2.68	+1.13	173
25 to 34 years	2.03	2.70	+ .67	133
35 to 44 years	2.74	3.13	+ .39	114
45 to 54 years	3.04	4.27	+1.23	140
55 to 64 years	2.16	4.33	+2.17	200
65 years and over	1.11	1.44	+ .33	130

The preceding table, derived from English experience, requires no further comment except that it may be pointed out that the data under observation are far from sufficient to warrant definite conclusions. The occupation has been investigated in the United States by Hayhurst, with regard to 10 establishments in Ohio, employing

539 persons, of whom all but 14 were males. Only 50 of the employees were over 40 years of age. There were no special complaints of importance, except as relating to the ventilation of lithographic workrooms. Neither the fume nor dust hazard seemed to be of serious importance. W. Gilman Thompson only briefly refers to lithographers, stating that they suffer from sedentary work and close application, resulting in dyspepsia and anemia, and that they have a somewhat high mortality from tuberculosis.

MORTALITY OF LITHOGRAPHERS—INDUSTRIAL INSURANCE EXPERIENCE.

The conclusions based upon Table 108 are sustained by the industrial insurance experience data of the Prudential Co. for the period 1897 to 1914, according to which, out of 325 deaths from all causes, 125, or 38.3 per cent, were from pulmonary tuberculosis.

TABLE 108.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG LITHOGRAPHERS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, COMPARED WITH THAT OF ALL MALES IN UNITED STATES REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of lithographers, 1897 to 1914, from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Lithographers.	Males in registration area, 1900 to 1913
15 to 24 years	70	37	52.9	27.0
25 to 34 years	81	42	51.9	30.5
35 to 44 years	69	27	39.1	23.4
45 to 54 years	53	13	24.5	14.7
55 to 64 years	32	4	12.5	7.9
65 years and over	19	2	10.5	2.6
Age unknown	1			
Total, 15 years and over	325	125	38.3	13.9

GENERAL CONCLUSIONS.

The mortality from pulmonary tuberculosis is, therefore, extremely high in this occupation at ages under 45 and in marked contrast to the mortality from this disease among the male population of the registration area. The statistics, though limited, may be accepted as conclusive and indicative of more or less unsatisfactory sanitary conditions common to the lithographic industry. For reasons partly inherent in the occupation, ventilating devices are often quite defective and occasionally impracticable. The dust hazard is only one of several which tend to make this employment a particularly unhealthy one, and this conclusion is sustained by the fact that out of 325 deaths of lithographers at known ages from all causes, only 19, or 5.9 per cent, were of ages 45 and over.

It is regrettable that the mortality of lithographers was not separately considered in the occupational mortality statistics of the Division of Vital Statistics of the United States Census Bureau, in which lithographers are combined with printers and pressmen. It has been observed in this connection by Kober, in Kober and Hanson's "Diseases of Occupation and Vocational Hygiene" (p. 614), that the work of chromolithography "is often carried on under unfavorable hygienic conditions as regards light, air space, and ventilation, which is all the more regrettable, as some of the processes involve the employment of injurious agents, such as arsenic pigments, chromium, lead, and bronze powder." It is said further that—

> The lithographic process varies in different establishments; the design or picture may be engraved by means of a diamond or steel needle upon a fine-grained sandstone, generally imported from Bavaria, or the drawing may be made upon the stone with a greasy composition. In photolithography the printing surface is largely prepared by a photographic process. In all of the processes of chromolithography the stone is dampened on those portions of the design which are not to appear in the first printing; this prevents taking the ink or colors. The actual application of colors and presswork is performed by another set of operatives. According to Leiser (Weyl's Handbuch der Gewerbekrankheiten, 1908, p. 339), in a total membership of 11,807 employees in this industry in Berlin during 1904, 2,002 males and 1,840 females, or 32.6 per cent, were reported sick, with 90 deaths; of the sick about 12 per cent suffered from tuberculosis; 11 per cent had skin affections, especially obstinate forms of eczema caused by contact with acid dips, bronzing powder, toxic color pigments, impure turpentine, etc.; 10.5 per cent of the sick suffered from disorders of the digestive system; and 19 per cent of the females were anæmic. There were 356 accidents, mostly contusions of the fingers contracted in presswork. Cohen estimates that about 45 per cent of the lithographers suffered from near sight or other visual defects.

The possible serious exposure to bronze dust in chromolithography can not be discussed on account of the want of precise and conclusive data. As far as the available information derived from fairly trustworthy sources justifies a preliminary conclusion, there does not appear to be an excessive incidence of pulmonary tuberculosis among men employed in the manufacture of bronze powder. As regards the bronzing process in chromolithography, Kober observes that this may be done by the dry or wet method or by hand or machinery, and that in spite of the metallic covering of the machinery and methods of exhaust ventilation the bronze powder escapes freely into the air and the employees who tend the machine "wear handkerchiefs over the nose and mouth" and "look pale and unhealthy, and all show the characteristic green perspiration due to contact with bronze." The great majority of employees, however, he remarks, appear to be healthy, which no doubt has reference to the men not directly connected with dust-producing processes. In the absence of more conclusive information and the required statistical evidence derived from official or insurance sources, no final conclusion can be arrived at further than that with reference to lithographers as a class the evidence is entirely sufficient to prove the excessive incidence of pulmonary tuberculosis and the prevalence of more or less decidedly unsatisfactory sanitary conditions in the lithographic industry.

FOUNDRY-MEN AND MOLDERS

Foundry-men and molders are to a considerable degree exposed to the continuous inhalation of both metallic and mineral dusts. While the proportion of metallic dust is quantitatively small, it is probably the more injurious of the two, although its effects are modified by the relatively much larger amount of mineral dust. The industry is varied, of large extent, and widely distributed throughout the country. The conditions affecting health naturally vary, and chiefly so on account of the metal used in casting, which may be iron, steel, brass, etc. The employments in foundry practice are chiefly those of molders and clay mixers, of which molders, again, are subdivided into those who work at a bench, or in the making of small ware, and those who work on the floor or in the pits in the making of castings of larger size. Within recent years labor-saving appliances have been extensively introduced into the large foundries, chiefly in connection with iron and steel works, but corresponding progress has not been made in the smaller establishments. The introduction of machinery has led to the employment of much unskilled labor of low grade, which complicates the use of the available mortality returns. It is also necessary to take into consideration the not inconsiderable accident liability of men employed in foundries, and the occasional or general exposure to extreme heat and the liability to overstrain inseparable from the lifting of heavy weights of metal.

An investigation into the sanitary aspects of this employment made by the State board of health of Massachusetts disclosed the fact that at 14 foundries in which castings of all kinds were made, in 7 the conditions as to light, ventilation, and dust removal were very poor. Of 9 stove foundries inspected, 4 presented moderately bad and 1 distinctly bad conditions affecting the health of employees. In the polishing room of one factory, conducted under almost ideal conditions, the emery wheels were well-equipped with hoods and exhaust ventilators, but the report states that "the men, unmindful of the protection provided, habitually remove the hoods, and become covered with emery and iron particles."

In reporting in some detail upon the establishments found to be more or less unsatisfactory as to light, ventilation, and dust removal, the report states that one shop "employs 275 men, in low-studded, poorly lighted, unventilated buildings, in which there is no attempt to remove the dust arising from the processes of polishing and buffing, by hoods and exhaust ventilation. In the tumbling room the dust is so thick that objects a few feet distant can not clearly be made out. Many men refuse to work in this establishment in the hot months, on account of the excessive heat and general discomfort."

The high mortality of foundry-men and molders from pulmonary tuberculosis observed to occur at advanced ages is decidedly suggestive. Evidently the progress of the disease in these occupations is slow, and often, if not as a rule, assumes the form of fibroid phthisis. There can be no question of doubt that there is in these occupations an intimate connection between the continuous exposure to metallic and mineral dust inhalation and the relative frequency of the disease. Considering the nature of the dust inhaled, this is what would be expected. The dust being largely mineral, but partly metallic, the proportion of iron dust, while considerable, is not so excessive as the iron or steel dust inhaled by men engaged in cutlery grinding or file cutting. No doubt many of the dangers of the employment could be guarded against by attention to safety devices, chiefly respirators, to be worn during some of the mold-making processes. The employment, by its very nature, however, precludes radical methods of dust prevention, and the most effective safeguard would be short hours of labor and a more rational use of leisure hours and vacations.[1]

MORTALITY OF MOLDERS—INDUSTRIAL INSURANCE EXPERIENCE.

There are no official vital statistics of these occupations either for the United States or for England and Wales. The recorded industrial insurance mortality statistics of foundry-men and molders are very extensive and include 3,294 deaths from all causes, of which 758, or 23 per cent, were from pulmonary tuberculosis. Of the deaths of foundry-men and molders from nontuberculous respiratory diseases, 25 were from asthma, 51 from bronchitis, 463 from pneumonia, and 65 from other diseases of this class. If the deaths from pulmonary tuberculosis and from other respiratory diseases are combined, 41.3 per cent of the mortality of foundry-men and molders were from diseases of the lungs and air passages. The mortality of foundry-men and molders from pulmonary tuberculosis was excessive at all ages over 25, but the excess was most pronounced at ages 25 to 34, when out of every 100 deaths of foundry-men from all causes, 40.4 were from pulmonary tuberculosis, against a normal expected proportion of 30.5. The analysis of the mortality from pulmonary tuberculosis of foundry-men and molders in detail is set forth in Table 109.

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[1] For a brief but practically useful account of occupational hazards in foundries, see "Practical Safety Methods and Devices," by George A. Cowee, New York, 1916.

TABLE 109.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG FOUNDRY-MEN AND MOLDERS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, COMPARED WITH THAT OF ALL MALES IN UNITED STATES REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of foundry-men and molders, 1897 to 1914, from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Foundry-men and molders.	Males in registration area, 1900 to 1913.
15 to 24 years	266	63	23.7	27.0
25 to 34 years	540	218	40.4	30.5
35 to 44 years	694	213	30.7	23.4
45 to 54 years	690	149	21.6	14.7
55 to 64 years	624	87	13.9	7.9
65 years and over	480	28	5.8	2.6
Total, 15 years and over	3,294	758	23.0	13.9

The preceding observations and statistical data, derived from industrial insurance mortality experience, confirm the conclusion that this employment is more or less injurious to health, and that the degree of frequency of pulmonary tuberculosis is excessive at ages 25 and over.

SANITARY CONDITIONS IN MASSACHUSETTS FOUNDRIES.

The sanitary conditions in foundries have been investigated by the Massachusetts State Board of Health and reported upon under date of April, 1911. Two hundred and nine foundries were inspected, including a large variety of processes of more or less importance from a hygienic point of view, but with special reference to extremes of temperature, and more or less irritating dust, gases, and vapors. Many of the foundries inspected were found to be improperly heated during the winter months, and the workmen were said to suffer more or less discomfort from the cold. In the immediate vicinity of the furnaces, however, particularly in the pouring of the metal, the heat was apt to be excessive. Gases and vapors were ascertained to prevail in some instances to an injurious degree, and especially was this found to be the case in brass foundries, with reference to the occurrence of so-called brass-founders' chills. It is a fair assumption that unfavorable temperature conditions and continuous exposure to noxious vapors must tend in a measure to reduce vitality and predispose to diseases, particularly of the respiratory organs, for as has been thoroughly well established for the metal mining industries, a preexisting condition of fibroid phthisis materially increases the liability to pulmonary tuberculosis. Fibroid phthisis contracted in consequence of dust exposure predisposes to pulmonary tuberculosis. The same conclusion applies to other unfavorable health conditions tending toward a lowering of vital resistance and an increased predisposition to particular specific diseases.

DUST EXPOSURE IN SAND BLASTING.

In the Massachusetts investigation of foundries it was found that the floors, benches, and the hands of operatives were covered with sand dust, and it is explained that the dry sand from which the cores are made is sifted on a fine wire netting, a process which gives rise to considerable fine dust. This process, however, is not usually carried on to any prolonged extent, but is done, for the most part, several times a week for only a few hours at a time. In one foundry the dust generated was decidedly objectionable, and upon the suggestion of the State inspector of health a covered sifter was provided to remove this source of annoyance. The most dusty process was ascertained to be the cleaning of castings, elsewhere briefly referred to under sand blasting. It is explained in this connection that—

> Castings are cleaned in tumbling mills, by sand blasts, emery wheels, or by hand with wire brushes. The tumbling mills are barrel-like chambers in which the castings are placed, together with small pieces of scrap iron. After the doors are closed, power is applied and the mills are set in a rotary motion. From the constant action of the castings upon each other and upon the scrap iron the surfaces are smoothed and the castings are cleaned of any sand which may be adherent. The dust generated by this process was, in most foundries, removed by exhausts. Moreover, these mills were usually located in some corner away from the workmen who did not have to attend to them during operation. The emery wheels on which the castings were cleaned were in many cases provided with hoods and exhausts.

These observations apply in a general way to modern foundries, but exceptions are sufficiently numerous to suggest the urgency of qualified and continuous supervision of the processes referred to. Neglect in this direction is invariably followed by health-injurious consequences, for as pointed out in the Massachusetts report—

> A serious exposure to fine dry sand was observed in those foundries where sand blasts were in use for cleaning the castings. This process, which is usually carried on in a room separated from the rest of the foundry, consists of playing a stream of fine dry sand, by means of compressed air, upon the castings. So great is the force of the sand stream that the steel nozzle which is used is quickly cut through. In some foundries exhaust fans and hoods were provided to carry off the dust, although in spite of this precaution the rooms were so filled with dust while the sand blasts were in operation that objects could not be clearly seen. When doing this work the workmen usually wore masks to protect the eyes. These masks, however, did not prevent the inhalation of dust, which appeared to enter the respiratory passages with a good deal of force. In one factory a man was observed to wear a helmet with a tubing through which fresh air was supplied from the outside. In another foundry such a helmet was provided, but the man did not use it "as it was too much bother to put it on and take it off." The length of time a man can keep at

this work is said to be short; in about a year or a year and a half he begins to show the effects of the work and is forced to leave.

PHYSICAL EXAMINATION OF MOLDERS IN THE FALL RIVER DISTRICT.

The foregoing observations have been quoted in full as evidence of the thoroughness with which the Massachusetts investigation was carried out. In the Fall River district physical examinations were made of 320 molders, with the following results: Bronchitis, asthma, and emphysema were ascertained in 41, or 12.8 per cent, of the molders examined. In addition thereto 39, or 12.2 per cent. were suffering from diseases of the heart, chiefly valvular disease or dilation; and 23, or 7.2 per cent, were suffering from diseases of the kidneys. In the aggregate, of the 320 examined 103, or 32.2 per cent, were found to be in a more or less serious condition of ill health. The ages of those examined ranged from 45 to 72. so that the conclusions apply entirely to molders well advanced in years, and no doubt for a considerable period engaged in the occupation.

NATURE AND PROPERTIES OF MOLDING SANDS AND DUSTS.

In the main, the health-injurious exposure is to the highly comminuted sand disseminated in the form of dust throughout the foundries, but chiefly in connection with cleaning and so-called sand blasting processes. The nature and properties of molding sands have been described by Mr. Percy Longmuir before the British Foundrymen's Association, in the Engineering Magazine.[1] Sand used for casting iron molds usually contains 84 per cent of silica and, in addition thereto, varying amounts of alumina, magnesia, lime, and metallic oxides. The pure silica is, however, recognized as the most injurious form of dust, but especially so when very finely comminuted, as is generally the case in molding processes. The health aspects of foundry work are, therefore, of special importance. but particularly so with reference to the control of the needless degree of dust exposure. What can be done in this connection is emphasized in a brief reference to the subject in the annual report of the chief inspector of factories and workshops for the year 1913, in which it is said that—

> Early in 1913 the prevention of dust in various departments of iron foundries was discussed at Falkirk with representative employers, and it was agreed that steps should be taken to improve the conditions in dressing, grinding, and fitting shops. Satisfactory arrangements have already been installed in some of the foundries, and before long it is hoped that all principal machines will be dealt

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[1] Engineering Magazine, vol. 30, March, 1906, pp. 909–911.

with. Experiments are also to be tried to devise means for carrying off dust generated by the hand brushing of castings, as this operation frequently leads to most undesirable conditions. Meanwhile some effort is being made to keep floors cleaner, so as to reduce the dust stirred up by the movements of the workers.

FOUNDRY INVESTIGATIONS IN OHIO.

Quite recently, also, the conditions of employment in iron foundries have been investigated by Hayhurst, of the Ohio State Board of Health, including 43 establishments in 14 cities, employing a total of 4,721 wage earners. Foundry processes, it is said, are carried on in connection with a variety of industries, chiefly, however, foundry and machine shop products, iron and steel mills, stoves and furnaces, agricultural implements, automobiles and parts, musical instruments, brass and bronze products, electrical apparatus, etc. Reference is made to a report by the financier of the International Molders' Union of North America to the effect that, out of 204 deaths in the Ohio branch of the molders' union in the five-year period 1909 to 1913, the chief causes of death were pneumonia, 30, or 14.7 per cent; heart disease, 30, or 14.7 per cent; tuberculosis, 27, or 13.2 per cent; and violence, 18, or 8.8 per cent. With reference to the experience of the same organization, it is said that—

> We can well understand that foundry conditions are such as to promote the prevalence of both throat and lung disorders, and also rheumatism. The violent changes in temperature, the drafts and dampness of the foundry, are conducive to suffering of this kind. It might truly be said that rheumatism in its several forms appears to be the nearest approach, if any, to what might be designated as an " occupational disease."

These observations were in a large measure confirmed by the investigations of Hayhurst, who states that—

> The presence of foundry dust appeared a negligible hazard in 7 places, fairly so in 17 more, and bad in the remaining 19. This dust was composed chiefly of mold sand, iron oxides, iron, dross, slag, cinders, and dirt. Of these the first is to be considered the most harmful. While it is practically impossible to avoid dust in iron foundries, the presence of subprocesses, such as casting cleaning, and furnacing, as well as other processes, which might be carried on in separate quarters, add greatly to the amount of fine dust floating in the air.

AIR CONTAMINATION BY GAS AND SMOKE.

Further reference is made to air contamination by mold fumes, gas fumes, smoke, and steam, and in a number of work places the air was badly vitiated during the winter season by the presence of coke-burning braziers used for heating, placed about in the quarters and yielding immense amounts of invisible coke gas due to the absence of flue connections to the outside. Cold, due either to the lack of efficient heating or to the rush of cool drafts, was considered a hazard to many workers in at least 15 of the places inspected. With reference thereto it is said by Hayhurst that—

> It is but natural that chilling of certain muscles and groups of muscles, which at intervals must be called into sudden severe straining actions, usually in hot places, should be greatly affected with sprains and rheumatism, shown as lumbago, wry neck, sciatica, neuritis, severe chest and shoulder pains, stiffness of joints, etc. Particularly is this condition favored by the going out-of-doors to closets, or at noontimes, or going home while wearing sweaty underclothes.

The results of the inquiry are summarized in the conclusion that—

> Founding is an example of an industry which in itself should be harmless; in fact, should promote health and longevity the same as any application requiring the general use of nearly all of the body functions. It is rendered dangerous chiefly because it is done indoors. On this account a great many precautions are necessary to be taken, as indicated, including the general medical supervision of the workers.

DUST EXPOSURE IN CASTING CLEANING.

With special reference to casting cleaning it is said that this is necessarily a very dusty process, as usually performed, and whether done by hand or steel brushes or with sand and air blasts, or by knocking and tapping, laborers so engaged should be protected from the dust, probably best by helmets supplied with compressed-air blasts, and the tumbling of small pieces or cleaning within inclosures or other dust-confining means should be used wherever possible.

GENERAL CONCLUSIONS.

Regardless of the foregoing conditions, which are quite generally known and understood, there has not thus far been the required degree of sanitary progress urgently called for by the highest considerations of the health and longevity of the men employed. The special liability to pulmonary tuberculosis as brought out by the statistical analysis of the available mortality data is confirmed by specialized investigations, summarized in an editorial note on tuberculosis among metal molders in Massachusetts, in the July (1914) issue of the Journal of the Massachusetts State Sanatoria, where it is said that—

> The chief factors, then, in the molder's life in connection with the development of tuberculosis are the exhausting nature of the work, the overheat and subsequent exposure while exhausted to cold outdoor air, the exposure to dust and gases, and, as stated, the exposure of certain molders to the debilitating effects of the fumes of poisonous metals. And to these must be added that factor so common to

all exhausting occupations, the abuse of alcohol, which appears to be almost a direct result of the nature of the work.[1]

CORE MAKERS.

Core making is an essential branch of foundry practice. This occupation gives employment to a considerable number of young persons, mostly boys, but of late years girls have been drawn into the trade, although it is held that the more arduous duties and surrounding conditions of the occupation are unsuited to the female sex. No qualified investigation appears to have been made into the health conditions of this employment, but in a general way the conditions approximate those of foundry practice in general.[2] There is a considerable exposure to both mineral and metallic dust, but the fact that large numbers follow this occupation for only a comparatively short time no doubt prevents the more serious results which would follow if the exposure were continued for many years.

SANITARY CONDITIONS IN FOUNDRIES.

The process of core making in connection with foundries is, of course, quite general to the iron and steel industry, the brass industry, etc. The general exposure, however, is rather to mineral dust than to metallic dust, although under given conditions the latter may assume prior importance. The dust in connection with the core-making process is described by Hayhurst[3] as consisting of sand, earths, and mold powders, but this conclusion no doubt was one based upon general observation rather than upon microscopical analysis. Among related sanitary features injurious to health Hayhurst refers to dampness, poor light, and poor aeration, the latter, of course, being chiefly due to the fumes and smoke. Variations in temperature conditions are also noticed, and fatigue is mentioned as a considerable hazard in the majority of the work places investigated. The chief complaint of the workers was the breathing of burned-gas fumes and smoke; but apparently no specific complaint was made of health-injurious dust.

NEW YORK STATE FACTORY INVESTIGATION.

The condition of foundries was inquired into by the New York State Factory Investigating Commission, who directed particular attention to the employment of women, chiefly in connection with core-making processes.[1] They state, as a result of their investigation, that molders were found to suffer from rheumatism, pulmonary diseases, and kidney troubles, which by implication applies also to core makers. They refer to the fumes and the heavy dust from the castings cleaned in the workrooms, which, being inhaled by the workers, render them more or less susceptible to all forms of respiratory diseases. They give expression to the opinion that "the employment of women in work of this kind in the foundries of the State should be prohibited."

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[1] American Journal of Public Health, 1914, p. 1254.

[2] Of special interest and value in this connection are the Rules and Regulations of the New York State Department of Labor regarding foundries and work in core-making rooms in which women are employed. (Labor Law and the Industrial Code, Albany, 1916, Rules 582–585.)

[3] Core making is discussed by Hayhurst in the Ohio State Bulletin of the Board of Health, February, 1915, p. 165.

MORTALITY OF CORE MAKERS—INDUSTRIAL INSURANCE EXPERIENCE.

The only available vital statistics of core makers are those derived from industrial insurance experience, including 357 deaths, of which 105, or 29.4 per cent, are from pulmonary tuberculosis. The details of the mortality are shown in Table 110.

TABLE 110.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG CORE MAKERS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, COMPARED WITH THAT OF ALL MALES IN UNITED STATES REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of core makers, 1897 to 1914, from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Core makers.	Males in registration area, 1900 to 1913.
15 to 24 years	113	36	31.9	27.0
25 to 34 years	98	42	42.9	30.5
35 to 44 years	63	19	30.2	23.4
45 to 54 years	42	5	11.9	14.7
55 to 64 years	26	3	11.5	7.9
65 years and over	15			2.6
Total, 15 years and over	357	105	29.4	13.9

When considered by divisional periods of life it appears that the proportionate mortality from pulmonary tuberculosis is highest at ages 25 to 34, when out of the mortality from all causes 42.9 per cent are from this disease, against 30.5 per cent expected on the basis of the mortality experience for the United States registration area. There are no corresponding statistics available for women. The data suggest the importance of further investigation and the possibility of a material improvement in sanitary conditions in consequence of the use of dust-laying devices. It may be said in conclusion that, according to the United States census of 1910, the number of male core makers was 16,479, and of female core makers, 1,836. A considerable portion of core makers of both sexes were under 20 years of age.

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[1] For a brief discussion of the employment of women in core rooms see New York State Factory Investigating Commission Report for 1913, Vol. I, pp. 255–263.

GENERAL CONCLUSIONS.

Core making is so generally carried on in connection with foundries that the occupation is frequently combined with molders, etc. Core makers in brass and iron foundries are briefly referred to by Kober and Hanson in their recent work on "Diseases of Occupation and Vocational Hygiene," but the observations are quite inadequate and inconclusive. In view of the fact that a large proportion of women are employed as core makers, it is reasonable to assume that with them the health-injurious consequences are more serious on account of dust exposure than in the case of men more resistant to disease and more inclined to change their occupation. Kober observes in this connection that core and mold makers are "exposed to the inhalation of large quantities of dust, especially in sifting the sand for the cores and in dusting the completed molds with powdered charcoal and graphite." He also remarks that female labor is often employed in the making of cores for small castings, and that the men engaged in breaking up the hot molds "naturally inhale large quantities of dust," determined by Ahrens on the basis of German investigations to amount to 28 mg. of dust per cubic meter in the air of foundry rooms, and by Hesse to amount to 71.7 mg. per cubic meter in the air of the cleaning and polishing room, which it is calculated would subject each operative to the inhalation of 42 grams of dust per annum. It is self-evident that the occupation is one which requires thoroughly well-considered methods of factory supervision if the readily apparent dust hazards are to be reduced to a harmless minimum. On account of the considerable employment of relatively young persons, including women, in core-making processes, intelligent supervision and control are urgently required.

THE GLASS INDUSTRY.

The glass industry in the United States in 1909 gave employment to some 69,000 wage earners, of whom about 5 per cent were children under 16 years of age. The industry is a varied one, including among others the manufacture of blown and pressed ware, of window glass and plate glass, and finally of so-called crystal or cut glass, which for the present purpose is considered as a separate industry. The labor division of the trade includes numerous and well-defined occupations, each of which is subject to more or less injurious circumstances, but of these the handling of materials and the mixing are the most liable to the risk of continuous inhalation of mineral dust. The most important employment is that of the glass blower, but there are few accurate statistics which separate this employment from the industry as a whole. For the present purpose, however, it has seemed best, as far as practicable, to consider separately the mortality of glass blowers, although the medical and statistical observations subsequently to be quoted refer more or less to glassworkers as a class. Changes in manufacturing processes and the introduction of labor-saving machinery have resulted in sanitary improvements, which in consequence have had a favorable effect upon the health of glass-blowers, at least in the United States, as far as the rather fragmentary statistical data can be relied upon. Among glassworkers as a class pulmonary tuberculosis is of exceptional frequency, in addition to which there is a comparatively high mortality from other respiratory diseases, lead poisoning, and heat prostration.[1]

EARLY OBSERVATIONS ON THE HEALTH OF GLASSWORKERS.

Thackrah, writing in 1832, held that glassworkers as a class were liable to catarrh and cough, but not to pleurisy and pneumonia. He commented upon the appearance of a fine dust at the furnaces which, however, in his opinion did not produce any marked effect on the health of the operatives. He also mentioned individual cases of glassworkers remaining at their employment at ages 70 to 80, but in the majority of instances failing eyesight at ages 50 to 60 disqualified for the employment. Thackrah's account of this occupation was, however, very superficial, and some of his conclusions were not at all in conformity to the facts as reported by other authorities. Tracy, writing in 1879, held that—

> In the manufacture of glass the workmen who grind and powder the siliceous material inhale great quantities of very irritating dust and suffer from constant hacking cough and conjunctivitis. It is rare to find a sound man among them and they are not able to continue long at the work. According to Hirt, they should not be allowed to labor, at a stretch, more than two or three weeks, and should then work at something else, or, at any rate, give up this occupation for at least double the working time. In this way, by the use of relays, the health of the men may be sustained.[2]

ENGLISH OCCUPATIONAL MORTALITY STATISTICS.

As shown by the census returns the actual numbers, as well as percentages, of glassworkers at advanced ages are surprisingly small. It is evident that the rapid diminution of the number at work after age 35 must be partly, at least, the result of a high death rate at the younger ages, and in particular due to an excessive mortality from pulmonary tuberculosis, which at this period of life causes from one-third to one-half of the deaths from all causes. Tatham, in Oliver's "Dangerous Trades" (p. 139), considers this employment at some length, and his observations, based largely upon English mortality data, are quoted in part as follows:

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[1] See. Working Conditions and Efficiency as Affected by Heat, by Basil M. Manly, in Report on Conditions of Employment in the Iron and Steel Industry. U. S. Bureau of Labor Statistics, Vol. III, 1912, pp. 287–332.

[2] Buck's Hygiene and Public Health, Vol. II, pp. 36, 37.

> The making, blowing, and engraving of glass occupies a prominent place among unhealthy trades for several reasons. In the first place, the workers are exposed to extreme variations of temperature—in some processes, that of glass blowing especially, the operatives are constantly exposed to the intense heat of the furnace, as well as to that which radiates from the pots of molten glass which they are engaged in blowing. The intense heat and profuse sweating naturally induce painful thirst, which the workmen evidently allay by excessive drinking; this is shown by the fact that their mortality from alcoholism and from nervous disorders is nearly double that experienced by operatives in other trades. * * * The comparative mortality figure for glass makers is 1,487, and is, therefore, in excess of the average by 56 per cent. Phthisis and diseases of the respiratory system are especially fatal to workmen in this industry, and they suffer more severely than other occupied males from diseases of the circulatory, digestive, and urinary systems, as well as from cancer. Since 1881 the mortality of glassworkers has increased considerably, and this is true of the younger as well as the older workers in this industry.

The English mortality statistics upon which these conclusions rest include 1,092 deaths of glassworkers, and of this number 229, or 21 per cent, died from pulmonary tuberculosis. At ages 25 to 34, however, out of 177 deaths of glassworkers from all causes, 79, or 44.6 per cent, were caused by this disease. Of the mortality from other causes, bronchitis caused 146 deaths, pneumonia 123, and other respiratory diseases 25. These combined with deaths due to pulmonary tuberculosis make a total of 523, or 47.9 per cent, from diseases of the lungs and air passages in the mortality of glassworkers from all causes. The most recent English mortality statistics of glass manufacture are for the three years ending with 1902, referred to in the Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales, in part as follows:

> In this occupation the death rates exceed the standard for occupied and retired males at all stages of life by proportions ranging from 12 to 32 per cent. In the main working period the comparative mortality figure is 1,260, or 25 per cent above the standard. The excess of mortality among these workers is most marked in the case of plumbism, phthisis, respiratory diseases, and Bright's disease; they also suffer heavily from influenza and from diseases of the nervous and circulatory systems. The mortality from alcoholism, accident, and suicide, however, is below the average.

COMPARATIVE MORTALITY FROM ALL CAUSES AND FROM DISEASES OF THE LUNGS.

The recent English mortality statistics for glassworkers are quite conclusive of the more or less unfavorable effect of this industry on health. In Table 111 the mortality from all causes among men in this group is compared with that of occupied males generally, and the result is decidedly suggestive of conditions in this trade more or less unfavorable to life and health. The excess in the general death rate of glassworkers is met with at all ages, but the relative and actual excesses are greatest with advancing years, being 6.41 per 1,000 at ages 45 to 54, 10.83 at 55 to 64, and 30.99 at 65 and over.

TABLE 111.—MORTALITY FROM ALL CAUSES AMONG GLASSWORKERS, COMPARED WITH THAT OF ALL OCCUPIED MALES, IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[Source: Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 for all occupied males.	Death rate for glassworkers.		
		Rate per 1,000.	Greater(+) or less (—) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years	2.44	3.22	+ 0.78	132
20 to 24 years	4.41	5.09	+ .68	115
25 to 34 years	6.01	6.74	+ .73	112
35 to 44 years	10.22	13.14	+ 2.92	129
45 to 54 years	17.73	24.14	+ 6.41	136
55 to 64 years	31.01	41.84	+10.83	135
65 years and over	88.39	119.38	+30.99	135

A more extended comparison is made in Table 112, in which the mortality of glassworkers from pulmonary tuberculosis and other respiratory diseases is compared with the normal mortality of occupied males from these diseases, by divisional periods of life. The comparison shows that the mortality from pulmonary tuberculosis is excessive at all ages, 15 to 64 inclusive, the excess being most marked at ages 35 to 54. The table further shows that the mortality of glassworkers from other respiratory diseases is excessive at all ages, the excess being most marked at ages 45 or over. The two tables derived from English experience fully confirm the previous conclusion that the mortality of glassworkers is excessive when comparison is made with the mortality of occupied males generally, and that this excess is largely because of the high degree of pulmonary tuberculosis frequency at ages 25 to 54, and a high mortality from other respiratory diseases at ages 35 or over.

TABLE 112.—MORTALITY FROM PULMONARY TUBERCULOSIS AND FROM OTHER DISEASES OF THE RESPIRATORY SYSTEM AMONG GLASSWORKERS, COMPARED WITH THAT OF ALL OCCUPIED MALES, IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[Source: Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Mortality from pulmonary tuberculosis.				Mortality from other diseases of the respiratory system.			
	Death rate per 1,000 for all occupied males.	Death rate for glassworkers.			Death rate per 1,000 for all occupied males.	Death rate for glassworkers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Ratio to rate for all occupied males.
15 to 19 years.....	0.54	0.56	+0.02	104	0.24	0.28	+ 0.04	117
20 to 24 years.....	1.55	1.81	+ .26	117	.48	.60	+ .12	125
25 to 34 years.....	2.03	2.88	+ .85	142	.77	.99	+ .22	129
35 to 44 years.....	2.74	4.56	+1.82	166	1.66	2.43	+ .77	146
45 to 54 years.....	3.04	4.87	+1.83	160	3.32	5.76	+ 2.44	173
55 to 64 years.....	2.16	2.97	+ .81	138	6.54	10.75	+ 4.21	164
65 years and over.	1.11	....	....	....	17.77	28.68	+10.91	161

MATERIALS USED IN GLASS MANUFACTURE.

The American glass industry has made considerable progress during recent years, but it may be questioned whether material modifications have been introduced into the manufacturing processes with special reference to necessary precautions against health-injurious conditions. The processes have been described in detail by Charles C. Dominge, who, with reference to the materials used, states that—

> The principal ingredients are washed and dried sand (white), lime, soda ash, potash and cullet, i. e., old broken glass and waste from melting pots. In some risks you may also find charcoal, oxide of lead, kelp, saltpeter, and cobalt (the latter used for coloring purposes). The lime and charcoal should be skidded and kept under a tight roof. The saltpeter or niter bags are likely to take fire spontaneously, therefore they should be removed from the building as soon as they are emptied.

The same authority describes the actual process of glass manufacture, in part, as follows:

> The above materials are mixed together, forming what is known as "batch," which is placed in a fire-clay pot, inserted in brick-inclosed pot furnace, with soft coal feed. This "batch" is then subjected to a temperature of approximately 2,500° F., which causes a perfect union and fusion of the materials. When this "batch" (i. e., glass ready for working) has cooled to a temperature of, say, 1,900° F., it is ready to be gathered. This is done by means of an iron blowpipe, which is thrust into the fire-clay pot, the molten glass clinging to the end of the pipe, resembling a ball. To make his material perfectly true, concentric with his iron pipe, the worker rolls it dextrously on an iron table or wooden block of special design. The glassmaker then blows

through the blowpipe, which inflates the batch "soap-bubble fashion," at the same time deftly shaping, altering, coaxing it into form and proportion with cunningly devised hand tools. The glass design is then placed in a water-jacketed mold, after which it goes to the brick-set tempering oven (known as "lehr"), which resembles a long, horizontal, brick-set boiler. These lehrs are fed by coke or gas, with the heat directly at the entrance, where the glass objects are placed on a traveling platform. About 1,000° F. is maintained here. The object is to give the glass the vital "temper," a provision against the piece bursting later in the decorator's hand. The glass cools slowly in its travel from the entrance where the heat is maintained to the other end, sometimes 40 to 125 feet long. Some of the heavier glass pieces require a week before they are removed from the oven.

Conditions of employment, with special reference to occupational hazard, vary, of course, according to the type of melting furnace used. Dust exposure is apparently more serious at the old style pot furnaces than at modern tank furnaces, which are usually built in three compartments or sections, each of which is heated to a different temperature. It is explained by Mr. Dominge that—

> The newer factories now use what is known as the melting tank or melting furnace or continuous tank. They are usually built in three compartments or sections, each of which is heated to a different temperature. The heated glass runs through an orifice near the base of the first section into the second section, where it is refined, after which it flows into the third compartment. The glass is now ready to be "gathered" by the glass worker. The temperature in the first section is about 2,500° F., the molten glass being at this stage colorless and translucent. The temperature in the second section is about 1,900° F., while the last section is so heated as to allow the glass to get into a form resembling paste.

Other processes involving heat and dust are the working of the so-called "glory holes," which are small, brick-inclosed circular furnaces used for heating glassware, for edge trimming, and other purposes; annealing furnaces, "which resemble somewhat a baker's oven, arranged in a series of three or four adjoining and heated by open and gas flames about waist high above the foundation." Into this "the hot glassware is introduced by hand and removed from one oven to the other, each being heated at a reduction in temperature to perfect annealing without rupture." The so-called "lehr" or tempering furnaces are of quite a different type, but the work involves about the same degree of temperature and dust exposure. Theoretically the most hazardous process is probably the so-called "pot making," which consists in the making of the furnace mold of fire clay molded by hand and the grinding up of old pots on the premises, with a considerable exposure to irritating mineral dust.[1]

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[1] A useful and descriptive account of the glass-making process occurs in the Annual Report of the New Jersey Bureau of Labor for the year 1906. The account includes all of the essential subdivisions of the industry and among others wooden-mold blowers, carboy blowers, lamp workers, batch makers, tending boys, shearers, etc.

LABOR CONDITIONS IN OHIO AND NEW YORK.

Hayhurst, in a brief description of glass-making processes, adds much new and useful information, stating that the process consists "in combining the various siliceous materials, alkalis, and other ingredients," and that the work is usually done in part by machinery and in part by hand labor, "the latter causing a great deal of dust because of shoveling and scooping." Dust in the air was noted in all work places investigated, and in the majority the conditions were bad, "due to the manner of handling the ingredients." With special reference to the mixing process it is suggested that "this work should be done in light, ventilated, dry quarters, above ground preferably, and, where mechanical means will not confine dust, workers should be furnished respirators of some sort and compelled to wear them. Those handling or exposed to poisonous dusts should be selected for intelligence, properly instructed, and seen by a physician at least once a month." This last suggestion has special reference to exposure to dust contamination by arsenic and red lead. The glass industry was also briefly inquired into by the New York State Factory Investigating Commission, who, in their second report, 1915 (Vol. II, p. 1115), refer to two different kinds of glass manufactured—a flint glass containing no lead and used principally for bottles and a glass containing lead compounds and other poisonous ingredients used chiefly for other purposes. It is explained that—

> The lead and other compounds are weighed and mixed in one room, then taken to the furnace room and mixed with a quantity of old glass; the entire mixture is then put into the furnace or pot and fused. The material in the pot is kept in a liquid state by high temperature, and into this the glass blower dips his pipe, taking out the amount he wishes to work. The greatest danger is from the handling of the dry ingredients and inhaling the dust created during the weighing and mixing.

Conditions in a typical mixing room are described, and it is said that during the mixing process no methods were employed "to carry away the dust created, but although the men were furnished respirators none were found to wear them." Evidence of lead poisoning was met with in a number of cases. The chief factor of neglect is the absence of precautions to guard against dust. Analyses of samples taken in the mixing room showed 3.3 mg. of lead per cubic meter of air. In another plant it was also found that no special precautions were employed, and while mixers were furnished respirators they would not wear them.

OCCUPATIONAL HAZARDS IN GLASS MANUFACTURE.

The most recent observations with regard to American conditions are by W. Gilman Thompson, who points out that—

> Glassworkers are subject to four principal forms of occupation hazard, namely, (1) exposure to great heat; (2) mechanical and chemical dust irritation; (3) poisoning by certain metals, such as lead oxide, zinc oxide or arsenic, used for coloring, etc.; (4) irritation of the eyes, caused by excessive heat and light.

It is explained that certain raw materials, such as flint, sand, quartz, powdered marble, limestone, soda, Glauber's salt, and potash, are finely ground and mixed, usually in open vessels, which he considers extremely dusty work. The temperature near the heating furnaces may reach 140° F., and the workmen in winter are, therefore, subjected to great changes of temperature in passing in and out. He explains further that—

> The result of inhalation of so many kinds of dust, from the raw materials used, the particles of ground glass, and the grinding materials, such as emery, etc., may give rise to pulmonary fibrosis and chronic bronchitis, which predispose to tuberculosis, but emphysema is not produced by glass blowing, as formerly supposed, despite the deep inspiration and prolonged expiration employed in the process. Emphysema is due to connective tissue changes in the lungs, and this disease is no more frequent among glass blowers than among any similar group of workmen when due regard is had for age, alcoholism, chronic pulmonary disease, and other predisposing factors.

PRACTICAL SANITARY PRECAUTIONS.

Thompson concludes these exceptionally interesting and useful observations with suggestions for the prevention of the more specific health-injurious conditions, as follows:

> The raw materials of glass, when being mixed, should be kept in covered receptacles as much as possible. The introduction of mechanical apparatus for glass blowing is doing much to mitigate the evils of this occupation when performed by mouth. Workmen should be examined by a physician, and all who are actively syphilitic excluded. The excessive heat from the furnaces may be guarded against by the use of asbestos screens and forcible introduction of a stream of cool air by means of a blow fan and duct. The eyes should be protected from the light and heat of the ovens by blue and gray goggles, and face masks may be worn to protect the skin of the face from blistering. All grinding rooms should be thoroughly cleaned daily and dust removed from the wheels, tables, and benches. The wheels should be incased as much as possible, and a strong exhaust duct should be operated in connection with them. Women and children should be excluded from the more hazardous departments of work. When handling sharp-edged glass vessels or working with lamp chimneys or thin bottles which are liable to explode, the hands

should be protected from injury by stout leather gloves. The grinding or cutting of quartz, crystal and jet, jade, and similar substances presents the same hazards to the respiratory system as those of glass grinding.

PRESENT-DAY LABOR CONDITIONS.

An exhaustive report upon labor conditions in the glass industry, with some extended references to sanitation and mortality, was included in the Senate report of the Commissioner of Labor on the "Condition of Woman and Child Wage Earners in the United States," Washington, 1911. This report includes a descriptive account of American glass-making processes, with observations on physical strain, interchange of occupations, dust, fumes, heat conditions, hours of labor, night work, etc. The mortality data are limited to glass blowers, elsewhere referred to, but in a general way the conclusions are applicable to glassworkers as a class. An extended descriptive account is included, from the Twenty-fourth Annual Report of the Bureau of Statistics of Labor and Industries of New Jersey, for 1901, which in a large measure is applicable to the present time. Attention is directed in this report to the improvement in working conditions introduced into glass works during the last two decades, but apparently much remains to be done to eliminate many objectionable features, especially such as refer to weather exposure, dampness, extreme heat, etc. It is said in this connection, however, that the improvements referred to "have removed some of the most serious causes of ill health, and they have greatly lessened the workmen's liability to contract disease while at work." A new element of danger, however, has been introduced in consequence of the extensive use of the so-called "continuous-tank furnace," which is said to be "severe upon all blowers and especially so on the older men who have been accustomed for years to work out of a pot furnace and only during the day." The heat of a tank furnace is much greater than that of a pot furnace, and "the alternation from day to night work weakens the system and reduces its power of resistance to attacks of disease." In concluding the report, it is pointed out that "it is certain that the environments of the workmen" (in glass factories) "create tendencies to disease, which, taken with their own lack of care have greatly aggravated attacks of sickness and in many cases caused them to assume characteristics very difficult to treat." Out of 314 cases of sickness specifically reported there were no cases of pulmonary tuberculosis, but there were 18 cases of pneumonia, 21 of inflammation of the lungs, 16 of inflammation of the throat, and 10 of bronchitis, aside from 76 cases of la grippe. It is self-evident, of course, that without a qualified medical examination of the employees the true extent of incipient tuberculosis could not be ascertained, and it is a reasonable assumption that in a more advanced condition of the disease the employee would not be at work. The statistics, however, suggest a relatively high frequency of respiratory diseases, which, as elsewhere observed in the general discussion of pneumoconiosis, is generally a predisposing condition in pulmonary tuberculosis.

SPECIFIC LIABILITY TO RESPIRATORY AND TUBERCULOUS DISEASES.

In so far as the evidence is available, the general conclusion is distinctly unfavorable regarding employment in the glass industry, with special reference to an increased liability to respiratory and tuberculous diseases. The rather inconclusive American evidence is quite fully confirmed by more extensive investigations into the hygiene of glassworkers in Germany[1] and Austria, referred to at some length in the report of the Commission of Labor on the condition of woman and child wage earners in the United States, with special reference to the glass industry, which should be referred to for more extended consideration. It seems sufficient for the present purpose to conclude these observations with the following extract from a translation of a German treatise on the diseases of glassworkers, by Dr. C. F. Schmidt:

> In the foreground among all diseases of the glass grinders stands the damage to the lungs by glass dust. This glass dust produces its effect by the mechanical irritation of the fine, sharp-angled and needle-pointed particles of glass. The dust particles may at length find their way into the lymph current and be deposited in the lungs and bronchial glands. Meinel, for example, found in the lungs of a glass blower a siliceous content of 30.7 per cent. Soon there supervenes a chronic catarrh of the larger bronchial tubes and bronchioles, the desquamated and inflamed mucous membrane of which finally affords a congenial soil for colonies of tubercle bacilli. Tuberculosis of the lungs makes early victims of a large proportion of the glass grinders. This is readily explicable, because, even as apprentices, they are exposed to the glass dust.

These observations, in addition to the foregoing statistical data and descriptive references, quite fully sustain the conclusion that employment in the glass industry must be considered as obviously injurious to health, with a measurable predisposition to pulmonary tuberculosis, partly, if not largely, on account of the considerable and continuous exposure to the inhalation of mineral dust.

INDUSTRIAL INSURANCE MORTALITY STATISTICS.

Since glass blowers and cutters are separately considered, and in view of the foregoing observations with special reference to mixers and handlers of raw materials, as well as workmen generally exposed to the dust hazard, the following vital statistics derived from the industrial insurance mortality experience of the Prudential Insurance Co. of America are only for glassworkers other than blowers and cutters. Table 113 includes 897 deaths of glassworkers not otherwise specified, and of this number 274, or 30.5 per cent, are deaths from pulmonary tuberculosis.

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[1] A most usful reference to hygienic conditions in the German glass industry occurs in the report of Consul General Frank Dillingham, reprinted in the Daily Consular and Trade Reports, Washington, Feb. 4, 1909.

TABLE 113.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG GLASSWORKERS, EXCLUDING BLOWERS AND CUTTERS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, COMPARED WITH THAT OF ALL MALES IN UNITED STATES REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of glassworkers, 1897 to 1914, from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Glassworkers.	Males in registration area, 1900-1913.
15 to 24 years	257	81	31.5	27.0
25 to 34 years	186	95	51.1	30.5
35 to 44 years	151	52	34.4	23.4
45 to 54 years	108	25	23.1	14.7
55 to 64 years	103	16	15.5	7.9
65 years and over	92	5	5.4	2.6
Total, 15 years and over	897	274	30.5	13.9

The table shows further that the proportionate mortality from pulmonary tuberculosis was extremely high among glassworkers not otherwise specified at ages 25 to 34, or 51.1 per cent, against the expected normal mortality of 30.5 per cent. The data are extremely suggestive and emphasize the importance and in fact the necessity of thorough-going methods of factory supervision and State control of industrial processes inimical to health and longevity.

MORTALITY OF GLASSWORKERS—UNITED STATES REGISTRATION AREA.

The mortality of glassworkers has been reported upon for the years 1908–1909 by the Division of Vital Statistics of the United States Census Bureau, but blowers and workers in general are included only for the year 1908. No explanation is made in the text of the report regarding the inclusion or exclusion of particular occupations for either one of the two years, during which the analysis was made by industries or occupations with reference to specific causes of death by divisional periods of life. According to the census report, out of 867 deaths of glassworkers from all causes 260, or 30 per cent, were from pulmonary tuberculosis. This is distinctly excessive when contrasted with 14.9 per cent for all occupied males and 16.7 per cent for plasterers. The details of the mortality by divisional periods of life are shown in Table 114.

TABLE 114.—PROPORTIONATE MORTALITY OF GLASSWORKERS FROM PULMONARY TUBERCULOSIS, UNITED STATES REGISTRATION AREA, 1908 TO 1909, BY AGE GROUPS.

Age at death.	Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent of deaths from all causes.
15 to 24 years	176	83	47.2
25 to 34 years	202	86	42.6
35 to 44 years	169	56	33.1
45 to 54 years	117	23	19.7
55 to 64 years	101	8	7.9
65 years and over	101	4	4.0
Age unknown	1		
Total, 15 years and over	867	260	30.0

TABLE 115.—PROPORTIONATE MORTALITY OF GLASSWORKERS FROM NONTUBERCULOUS RESPIRATORY DISEASES, UNITED STATES REGISTRATION AREA, 1908 TO 1909.

Cause of death.	Deaths from nontuberculous respiratory diseases.	
	Number.	Per cent of deaths from all causes.
Asthma	2	0.2
Bronchitis	5	.6
Pneumonia	67	7.7
Other nontuberculous respiratory diseases	6	.7
Total	80	9.2

According to Table 114 the proportionate mortality was excessive at all ages throughout the entire working period of life, but particularly so at ages 15 to 24, when out of the mortality of glassworkers from all causes 47.2 per cent were from pulmonary tuberculosis. The corresponding proportion for potters was 46.2 per cent, and for marble and stonecutters 26.2 per cent. At ages 25 to 34 the differences are less pronounced, the proportion of deaths from pulmonary tuberculosis having been 42.6 per cent of the mortality from all causes among glassworkers, against 44.4 per cent for potters and 43.5 per cent for marble and stonecutters. In a general way the table confirms other investigations and may be considered fairly conclusive, except in so far that the same applies to the glass industry in general rather than to specific occupations or employments subject to the most trying conditions of mineral dust exposure, complicated, of course, by physical strain, heat exposure, temperature changes, etc. Aside from the mortality of 30 per cent from pulmonary tuberculosis glassworkers show an additional mortality from nontuberculous respiratory diseases of 9.2 per cent, which compares with 12.5 per cent for potters and 12.2 per cent for marble and stone workers. As far as it is possible to judge, therefore, the mortality from nontuberculous respiratory diseases is not distinctly excessive, for in comparison the mortality of all occupied males is 10 per cent, or respectively, 7.8 per cent for pneumonia against 7.7 per cent for glassworkers, and 0.9 per cent for bronchitis against 0.6 per cent for glassworkers.

GENERAL CONCLUSIONS.

Employment in the glass industry, therefore, while predisposing to pulmonary tuberculosis, appears to have no directly measurable relation to the occurrence of nontuberculous respiratory diseases. This conclusion is of special importance on account of the assumption that heat exposure and sudden temperature changes, which are quite common to the glass industry, predispose decidedly to pneumonia and other nontuberculous respiratory diseases. In the American glass industry this is apparently not the case.

GLASS CUTTERS.

Glass cutters, including under this term all who are employed in the manufacture of crystal or so-called cut glass, constitute a separate and well-defined occupation division in glass manufacture.

SANITARY ASPECTS OF GLASS CUTTING AND POLISHING.

The most important employments are roughing, smoothing, polishing, and puttying, but of these the last named is the most injurious, chiefly because of a specific liability to lead poisoning. The sanitary aspects of the employment have received the special consideration of a British committee on dangerous trades, which, in its Third Interim Report, remarked with special reference to the injurious effects of putty powder in the form of dust that—

> It will thus be seen that all persons employed in places where "putty powder" is used, though themselves not handling it, are liable, through inhalation of the dust, to illness and even death through juxtaposition with those engaged in its use. Under existing circumstances the wet powder splashes onto the clothes not only of the polisher who uses it, but onto those of his neighbors; it gets dry after a time, comes off in fine dust, and enters the system either by inhalation through the lungs or by swallowing or through the pores of the skin.

Among other recommendations for the amelioration of the more or less health-injurious conditions inherent in this employment, the committee suggested that all persons engaged in the department of glass cutting and powdering, where so-called putty powder is used, should be examined once a month by the certifying surgeon for the district, who should be empowered to order temporary or permanent suspension of work.

EXPOSURE TO MINERAL AND METALLIC DUSTS.

Aside from the exposure to the inhalation of dust containing lead or other metallic ingredients, there is a further liability to the inhalation of considerable quantities of mineral dust in a large variety of forms. It would obviously be very difficult to estimate with even approximate accuracy the degree of lung injury resulting from dust exposure in glass cutting and polishing, but it is the opinion of qualified authorities that practically every branch of the trade is more or less affected, with a resulting excess in the mortality from pulmonary tuberculosis. Tracy comments briefly upon the health-injurious aspects of this occupation, in part as follows:

> But the most dangerous work is that of the grinders and polishers of cut glass. About 35 per cent of them have chronic pneumonia (phthisis), and their average age at death is variously given at from 30 to 42 years. Putégnat (de Lunéville) has described a peculiar form of gingivitis which he has observed among glass cutters, and which, he says, attacks 95 out of every 100 workmen. It comes on in about three months after the person begins work, and toward the sixth month is well developed. It attacks by preference the upper jaw, and is accompanied by the same blue line that is found in cases of lead poisoning. The acid secretion of the gums destroys the enamel of the teeth, which soon become pointed, brittle, and break off close to the alveoli, leaving a permanent stump. The gums remain soft and spongy, and the breath is very fetid. At no time is there any pain or hemorrhage. He supposes it to be caused by malnutrition, bad air, etc. (Tardieu.) These symptoms certainly appear suspiciously like those of lead poisoning, and the suspicion is rendered stronger by the fact that French flint glass contains about 20 per cent of lead, and that other symptoms of lead poisoning are not uncommon in glass cutters, as colic, constipation, muscular pains, etc. Garrod has noticed the frequency of gout among them, and brings it forward to support his theory of a connection between that disease and saturnine poisoning.
>
> The grinding or etching of glass by the sand blast fills the rooms with a dust composed of particles of sand and glass mingled. The business is a comparatively new one, and the workmen so far do not appear to be injured by it, with the exception of a slight tickling cough when they first begin work. The dust is rather coarse and heavy, and I am inclined to think it does not penetrate very far into the lungs, perhaps not even getting beyond the trachea, whence it is easily expectorated.

Lloyd also considered this employment, holding that—

> Flint glass contains lead, being chemically a compound of silicon (silicic acid) with an alkaline and an earthy base, the latter being

represented by lead. It is this flint, or lead, glass that is used for cut glass because of its brilliancy. The glass cutter's mill is a revolving disk of wrought or cast iron on which is fed a mixture of sand and water, with which the cutting and polishing are accomplished. In this process, which requires the artisan to bend closely over his mill, dust and fine particles of glass are given off. Emery and putty powder also are used, the latter containing lead. These are the noxious agents by which these cutters and polishers of flint glass acquire lead poisoning.

Unfortunately there are no official vital statistics of this occupation, since the comparatively small group of cutters of crystal glass is included in the census vital statistics with glassworkers generally. Cutters of crystal glass are continuously and considerably exposed to the inhalation of fine particles of mineral dust, which must indeed disastrously affect the lungs of the workmen, but in particular such as are otherwise predisposed to pulmonary tuberculosis. The suggestion of Oliver and others that crystal glass polishers and cutters should be periodically medically examined for cases of lead poisoning applies equally to the purpose of discovering incipient cases of tuberculosis more or less the result of the employment.[1]

MORTALITY OF GLASS CUTTERS—MEDICO-ACTUARIAL EXPERIENCE.

According to the medico-actuarial investigation, which, however, combines glass bevelers, grinders and cutters, excluding foremen and superintendents, the relative mortality from all causes was extremely high, or 46 per cent in excess of the normal. The details of this experience are shown in Table 116.

TABLE 116.—MORTALITY FROM ALL CAUSES AMONG GLASS BEVELERS, GRINDERS, AND CUTTERS, EXCLUDING FOREMEN AND SUPERINTENDENTS, BY AGE GROUPS.

[Medico-Actuarial Investigation.]

Age at death.	Number exposed to risk one year.	Actual deaths.	Expected deaths.	Ratio of actual to expected deaths.
15 to 29 years	4,857	26	22.24	117
30 to 39 years	3,187	33	17.45	189
40 to 49 years	813	9	7.73	116
50 to 59 years	193	6	3.43	175
60 years and over	39	3	1.75	171
Total	9,089	77	52.60	146

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[1] For additional references to the health-injurious circumstances in glass cutting and polishing, see the Reports of the Chief Inspector of Factories and Workshops for 1895, Vol. I, p. 36; 1896, p. 25; 1899, pp. 16, 313; 1900, p. 207; 1901, Part I, p. 220. For a descriptive account of the various manufacturing processes, see Scientific American for Apr. 30, 1904.

MORTALITY OF GLASS CUTTERS—INDUSTRIAL INSURANCE EXPERIENCE.

It is regrettable that the foregoing experience should not be available with reference to causes of death. The mortality from pulmonary tuberculosis among glassworkers is, however, clearly shown in Table 117, derived from the industrial insurance mortality experience of the Prudential Insurance Co. of America, for the period 1897 to 1914, including 220 deaths from all causes, of which 80, or 36.4 per cent, were from pulmonary tuberculosis.

TABLE 117.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG GLASS CUTTERS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, COMPARED WITH THAT OF ALL MALES IN UNITED STATES REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of glass cutters, 1897 to 1914, from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Glass cutters.	Males in registration area, 1900–1913.
15 to 24 years	53	21	39.6	27.0
25 to 34 years	55	28	50.9	30.5
35 to 44 years	48	20	41.7	23.4
45 to 54 years	28	6	21.4	14.7
55 to 64 years	24	2	8.3	7.9
65 years and over	11	3	27.3	2.6
Age unknown	1			
Total, 15 years and over	220	80	36.4	13.9

According to this table the proportionate mortality of glass cutters from pulmonary tuberculosis is highest at ages 25 to 34, when out of 55 deaths from all causes 28, or 50.9 per cent, are from pulmonary tuberculosis. The mortality from this disease, however, must be considered excessive at every divisional period of life. There appears to have been no material improvement in the health condition of glass cutters during recent years; and, with possibly the exception of the reduction of the liability to lead poisoning, there can be no question of doubt but that sanitary conditions are generally far from satisfactory and that effective dust-removing devices are frequently absent. There are no reasons for questioning the possibilities of a material improvement in the health conditions of this specific group of occupations in the glass industry, nor can the conclusion be called into question that the principal cause of ill health is the dust generated in connection with glass-cutting processes and inhaled to a more or less considerable and measurable degree.

LABOR CONDITIONS IN MASSACHUSETTS.

Glass cutting and polishing were reported upon in the Massachusetts investigation of 1907, but it should be considered that the industry is, relatively, of very limited extent in that State. It is said in the report referred to that—

> Operations which cause glass dust in the air are recognized as especially dangerous to health, such dust being quite as irritating as steel dust, if not more so. This being the case, glass cutting and polishing are conducted with a minimum of danger in the wet way. In cutting, the pattern is marked out with red lead or with graphite, and then the object is held against a rapidly revolving steel wheel upon which fine quartz sand and water are dropped continuously, or upon a wheel of fine emery and corundum. When the pattern has been cut out the glass is plunged into hydrofluoric acid in lead tanks, connected with the exhaust pipe of a steam-propelled blower. This smooths the cut surfaces, but acts on the uncut parts to such an extent as to make polishing necessary. This is done with pumice or rottenstone and water or oil on revolving brushes, and putty powder or rouge and wax on wooden wheels. The use of oil or water serves to prevent dust, and the employment of wooden shields protects the worker from being spattered with the mixture of oil and glass powder and other materials thrown off in the process. For successful work good light is very necessary, and in this respect all five of the establishments visited were found to be beyond criticism. The conditions as to ventilation and toilet arrangements were found to be equally commendable. All cutting and polishing is done by the wet method, and in no instance was any dust perceptible. In two of the establishments in which glass blowing also is carried on the employees are necessarily exposed to high temperatures and to the possible danger which resides in the use of blowpipes, which are introduced indiscriminately into the blowers' mouths. Otherwise no objectionable features were noted. The number of persons employed in the several factories ranged from about 30 to several hundred. As a class they appear to be of a rather high order of intelligence and to enjoy good health.

These observations should be accepted with caution for the reason stated.

LABOR CONDITIONS IN PENNSYLVANIA AND OHIO.

In Pennsylvania, where glass cutting is quite extensively developed, no qualified investigation has been made by official authority, but private inquiries have disclosed a considerable variation in sanitary conditions, sufficiently so to suggest the possibility of material and far-reaching improvements.

Hayhurst, in the Ohio survey of 1915, gives expression to the opinion that "the work at glass grinding was done only at intervals and created a great deal of dust." This may have reference to exceptional conditions in Ohio plants, for as a rule cut-glass grinding is a continuous process and relatively free from health-injurious dust when sufficient water is used and the surroundings are kept scrupulously clean. The dust danger rises chiefly from unsanitary conditions rather than from the grinding which, as a rule, is carried on by the wet process. The danger to be guarded against is rather the liability to lead poisoning, but there are reasons for believing that the occupation also involves, though only to a limited extent, an increased liability to pulmonary tuberculosis. The four essential processes of roughing, smoothing, polishing, and puttying all involve exposure to widely varying conditions, but the risk is most serious in the puttying, chiefly on account of the liability to lead poisoning. In this process a mixture of oxide of lead is used, which, by means of a brush wheel, is applied to the nearly finished article for the purpose of giving the same the brilliant polish, which is the most distinctive feature of the highest grade of cut glassware. A "dust," or rather "splash," is created, and small particles of the same are readily observed on the faces and hands of the operators. The hands are constantly dipped into a mixture of lead, putty, and water, and unquestionably some lead is occasionally introduced into the system in small quantities, either by inhalation or by habits of uncleanliness. Lead poisoning resulting from this occupation has, however, been very materially reduced during recent years, and cases of lead paralysis are now rarely met with.

Reference may be made here to a brief statement regarding glass polishing in the Report of the Chief Inspector of Factories and Workshops for 1898. The evidence is quite conclusive that in this country lead poisoning in glass cutting is less common than in the United Kingdom. The most recent investigations in this country have been reported upon by the New York State Factory Investigating Commission, 1913 (vol. 2, p. 1116), chiefly with reference to the risk of lead poisoning, but it is said in conclusion that "in this industry the principal measures to be taken are cleanliness, especially on the part of the worker; and while there may be some dust in the air, it is negligible, as the results of our analyses fail to show any lead present in the samples taken." This conclusion, of course, has reference only to lead and has no bearing upon the question of mineral dust in relation to lung diseases, whether of the tuberculous or nontuberculous variety.

GENERAL CONCLUSIONS.

In a general way it would seem that the available evidence regarding glass cutters and polishers indicates a very marked improvement in the hygienic conditions of the principal plants which have been thoroughly investigated and the practical elimination of lead poisoning. In the principal centers of the glass-cutting industry in the United States cases of lead paralysis are now extremely rare. The process of puttying has been largely eliminated and in place thereof the use of the method of dipping the nearly finished glassware into hydrofluoric acid has become quite general. The underlying cause of the practical elimination of lead poisoning is, however, the decidedly more sanitary condition of the shops, which by inference suggests a similar improvement in the partial control of the dust hazard. Processes of ventilation and dust removal have not been as thoroughly developed as would be desirable, but there can be no reasonable question of doubt as regards a material recent improvement in the health and longevity of glass cutters and polishers in contrast to the truly deplorable conditions prevailing in the past.

GLASS BLOWERS.

The hygiene of glass blowing with special reference to pulmonary tuberculosis is of exceptional interest as a labor problem in the glass industry. The number of blowers employed proportionate to the total number of wage earners is relatively large, and, from a wage point of view, the employment is of the first order of importance.

DESCRIPTIVE ACCOUNT OF GLASS-BLOWING PROCESSES.

In a descriptive account of the glass industry, published in the Pennsylvania Labor Report for 1888, it is stated that—

> The occupation of blowing requires great dexterity and nimbleness of the fingers to manipulate the glass; and while not laborious in the sense of requiring great muscular power, every limb and muscle is brought into use in molding a bottle, whether a large or small one. The blower in a shop is constantly on his feet, moving in a circle, and usually takes from six to seven steps to each bottle he molds. When it is considered that in making some sizes he molds from 175 to 200 dozen in a day we have some idea of the endurance required. There is scarcely an affliction that man is liable to that does not interfere with his work. The least sore on any of his fingers, hands, or feet, sore lips, sore throat, or toothache, or any of these, and he is obliged to lay off. The gaffer sits while at his work and is not liable to be laid up by so many ailments as the blower. Although subjected to heat, dust, and the gases that arise from the use of coal or oil in heating the glory hole, his workmanship is not impaired by most of the afflictions that disqualify a blower. Hence gaffers are usually superannuated blowers.

SPECIAL OCCUPATIONAL HAZARDS.

Health conditions vary considerably, according to the nature of the blowing process, whether for the purpose of bottle making,[1] carboy making, or window glass, etc. According to Sir Thomas Oliver—

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[1] For a brief but thoroughly scientific account of glass bottle manufacture from the mixing of the ingredients to the molding of bottles by machinery, see the Scientific American Supplement, No. 2135, for Dec. 2, 1916. With reference to the ingredients used it is said in part that "The basis of bottle glass is a silicious sand, to which is sometimes added limestone, together with sulphate or carbonate of soda. These ingredients, in pulverized form, are thrown into a large tank furnace, where they are melted and combined, forming a thick liquid of sirupy consistency. In the factories that make the better grades of glass such as tableware and window glass, it is periodically desirable to clean out their melting pots, and there is also considerable damaged material that must be discarded; that is called "cullet," and is sold to the bottle maker, who mixes it with his materials, together with all the damaged bottles that accumulate around the factory."

The relation of this process to dust exposure and health-injurious conditions is obvious.

> The risks to health incurred by makers of glass are mainly those due to exposure to excessively high temperatures, e. g., bronchial and pulmonary affections; many of the men die from phthisis. They bear pneumonia badly, owing to their intemperate habits. Dr. Scheele, in the Berlin Kleinische Wochenschrift, March, 1900, has drawn attention to what is known as "glass-blowers' mouth." Large swellings like air cushions can be seen and felt in some glass blowers, extending from the angle of the mouth to below the ears. The swellings look like mumps. They involve the parotid gland only. They crepitate under the finger and by pressure can be made to disappear. It is only recently that these swellings in the cheeks of glass blowers have attracted attention, and especially in France. The relaxation of the cheeks, the jous casees of French glass blowers, is by some attributed to a faulty method of blowing. From glass blowers under my care in the Newcastle Infirmary I have ascertained that the malady is not unknown among the men in the work on Tyneside. Dr. Scheele found that it was present in only 2.5 per cent of blowers, some of whom had worked for years. In those who had thus suffered the duct that leads from the interior of the mouth to the parotid gland had become dilated, owing to the repeated entrance of air into it under considerable pressure; the mucous membrane of the inside of the cheek, too, showed thick pale patches, plaques opalines, which Guinard regarded as the result of the great pressure and straining the buccal mucous membrane was exposed to during the act of blowing. Under ordinary forced expiration the pressure inside the closed mouth is equivalent to from 6 to 9 millimeters of mercury, but in glass blowing it may rise to 90 and even as high as 110 mm. In the course of an ordinary day a good workman will blow as many as from 600 to 700 bottles.

FREQUENCY OF LUNG DISEASES.

The foregoing observations are far from conclusive, but they emphasize the urgency of more extended investigations. A brief reference to lung affections in glass blowers occurs in an abstract of a paper on the subject by Prettin,[1] as follows:

> Prettin found that the muscles seem to adapt themselves to their task, so that glass blowers are not apparently more liable than others to have pulmonary emphysema. But, on the other hand, he found an unusually large proportion of tuberculous lesions among them. Fully 20 per cent of the workmen presented evidences of a tuberculous lung affection, while emphysema was observed in only 5 out of the 230 glass blowers examined. It was very slight in the 2 subjects between 40 and 50 years old, and the 3 others were 52 to 58 years old, and had been glass blowers for 34 to 43 years. He cites Fischer to the effect that not a single instance of emphysema was found in 500 members of military bands, as published in 1902.

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[1] Journal American Medical Association, Mar. 19, 1904.

GLASS BLOWERS' CATARACT.

Medical interest has rather been confined to the question of glass blowers' cataract, a description of which, however, is outside of the scope of the present discussion. The affliction is one of serious importance, especially with reference to workmen's compensation and as a medical problem in relation to the syphilitic infections. Since any and all diseases which impair physical efficiency or result in a diminution of disease resistance have an indirect bearing upon the frequency of pulmonary tuberculosis, the following reference to glass blowers' syphilis in the Medical Record (Feb. 11, 1888) is included:

> Prof. N. De Smet, of Brussels, in commenting upon a case of syphilis occurring in the mouth of a glass blower, referred to several epidemics which have been reported as having occurred among artisans of this description. He said that only two plans for preventing these outbreaks had been devised, viz, giving a separate movable mouthpiece to each man, and instituting frequent, rigorous, and periodical inspection of the persons of the employees. The first plan is always declared by the workmen to be impracticable, from the loss of time which would be occasioned by fitting the different mouthpieces on the tubes.
>
> The second would, of course, be resisted by the men, but he thinks their objections could be overcome by showing them the danger to themselves and their families which arises from the present system.

MORTALITY OF GLASS BLOWERS—MEDICO-ACTUARIAL EXPERIENCE.

The mortality of glass blowers not using machinery and excluding foremen and superintendents was investigated by the Medico-Actuarial Association, with the result shown in Table 118.

TABLE 118.—MORTALITY FROM ALL CAUSES AMONG GLASS BLOWERS NOT USING MACHINERY, EXCLUDING FOREMEN AND SUPERINTENDENTS, BY AGE GROUPS.

[Medico-Actuarial Investigation.]

Age at death.	Number exposed to risk one year.	Actual deaths.	Expected deaths.	Ratio of actual to expected deaths.
15 to 29 years	5,002	26	22.95	113
30 to 39 years	4,216	30	22.75	132
40 to 49 years	1,008	12	8.91	135
50 to 59 years	144	2	2.83	71
60 years and over	13	....	.46	....
Total	10,383	70	57.90	121

The experience shows that the actual mortality of this class of workmen is 21 per cent in excess of the expected, the excess being most marked at ages 30 to 49.

MORTALITY OF GLASS BLOWERS—INDUSTRIAL INSURANCE EXPERIENCE.

The only available statistics of glass blowers' mortality from pulmonary tuberculosis are the data derived from the industrial insurance experience of the Prudential Insurance Co. of America for the period 1897 to 1914, which includes 546 deaths from all causes, of which 175, or 32.1 per cent, were from pulmonary tuberculosis.

TABLE 119.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG GLASS BLOWERS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, COMPARED WITH THAT OF ALL MALES IN UNITED STATES REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of glass blowers, 1897–1914, from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Glass blowers.	Males in registration area, 1900–1913.
15 to 24 years	51	23	45.1	27.0
25 to 34 years	137	73	53.3	30.5
35 to 44 years	115	36	31.3	23.4
45 to 54 years	106	30	28.3	14.7
55 to 64 years	52	8	15.4	7.9
65 years and over	85	5	5.9	2.6
Total, 15 years and over	546	175	32.1	13.9

According to Table 119, the proportionate mortality from pulmonary tuberculosis is excessive at all ages, but especially so at ages 25 to 34, when of the deaths of glass blowers from all causes, 53.3 per cent are from pulmonary tuberculosis, against 30.5 per cent among males in the United States registration area. The table may be accepted as fairly conclusive, but, as said before, health and sanitary conditions vary considerably in the different branches of glass blowing, but no data are at present available which would permit of definite conclusions. It is, however, a safe assumption that carboy blowing, which requires much more strength than bottle blowing, is probably more injurious and involves an increased predisposition to pulmonary tuberculosis. How far the excessive liability to tuberculous diseases is increased by the dust factor can not be determined at the present time. The occupation group is one deserving of much more qualified medical and other technical consideration than it has heretofore received.

MORTALITY EXPERIENCE OF THE GLASS BOTTLE BLOWERS' ASSOCIATION.

The foregoing observations and conclusions are quite fully sustained by an analysis of the mortality of glass blowers, presented by the records of the Glass Bottle Blowers' Association of the United States and Canada for the period 1892 to 1908, inclusive, contained in the report of the United States Commissioner of Labor on the

Condition of Woman and Child Wage Earners in the United States, with special reference to the glass industry, Washington, 1911. The experience includes 898 deaths from all causes, of which 287, or 32.0 per cent, were from pulmonary tuberculosis. In addition, there were 8 deaths from other forms of tuberculosis, or 0.9 per cent of the mortality from all causes; 69, or 7.7 per cent, from pneumonia; and 28, or 3.1 per cent, from other diseases of the respiratory system. Combining the mortality from tuberculosis and nontuberculous respiratory diseases, the proportionate mortality from this group of causes in the mortality from all causes was 43.7 per cent. The mortality in detail, by divisional periods of life, is shown in the usual form in Table 120.

TABLE 120.—MORTALITY OF GLASS BLOWERS, GLASS BOTTLE BLOWERS' ASSOCIATION OF UNITED STATES AND CANADA, 1892 TO 1908.

Age at death.	Deaths from all causes.	Deaths from pulmonary tuberculosis.		Deaths from other tuberculous diseases.		Deaths from pneumonia.		Deaths from other respiratory diseases.	
		Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
15 to 24 years	48	24	50.0	....	....	5	10.4	2	4.2
25 to 34 years	266	119	44.7	5	1.9	20	7.5	4	1.5
35 to 44 years	272	93	34.2	3	1.1	27	9.9	7	2.6
45 to 54 years	140	34	24.3	....	....	7	5.0	5	3.6
55 to 64 years	86	9	10.5	....	....	3	3.5	3	3.5
65 years and over	74	4	5.4	....	....	7	9.5	7	9.5
Age unknown	12	4	33.3	....	....	....	....	....	....
Total, 15 years and over	898	287	32.0	8	.9	69	7.7	28	3.1

It would be outside of the purpose of the present investigation to enlarge upon the frequency occurrence of other causes, but it may be said in this connection, with special reference to alcoholism, that there were 7 deaths from this cause, or 0.78 per cent of the total, and 11 deaths from cirrhosis of the liver, or 1.22 per cent, which, however, can not be considered conclusive evidence regarding an excessive amount of gross intoxication among glassworkers, which is frequently assumed to be of relatively common occurrence. It is also suggestive that the mortality from pneumonia, which is often assumed to be increased in frequency by exposure to extreme heat and variable weather conditions, was not excessive in the experience referred to. The average age at death of all glass blowers was 41.4 years, and of those who died from pulmonary tuberculosis, 38.8 years.

SPECIFIC DISEASE LIABILITY OF GLASS BLOWERS.

The statistical analysis in the report referred to is amplified by extracts from reports on investigations into the hygiene of glassworkers in this country and Germany. According to an account of the diseases incident to the glass industry, in the Twenty-fourth Annual Report of the Bureau of Statistics of Labor and Industries of New Jersey for 1901, glassworkers are much exposed to unfavorable weather conditions, working, as they frequently do, in a temperature exposure of from 100° to 130°. It is said further, with reference to habits of life, etc., in the report of the United States Commissioner of Labor, that—

> Irregularity in eating and sleeping, disregard of ordinary precautions, the habitual use of large drafts of ice water, are the prime factors in creating acute attacks of dyspepsia and indigestion, from which glassworkers suffer so much, and imprudent and unnecessary exposure aggravate and intensify diseases which attack the air passages. There is scarcely a glass blower to be found who does not suffer from some form of catarrh. Forethought and care exercised in guarding against the change from a high temperature to a low one would greatly improve the health conditions of men who work in the intense heat of the glassworks. When a workman leaves the high temperature of the factory, say 90° to 100°, in midwinter to face the temperature outside, say 10° to 12°, his underclothing wet with perspiration, without preparing himself thoroughly for the great change, he certainly invites disease to fasten upon his throat and lungs or give a dangerous chill to the circulatory system no matter how stalwart his frame or how robust his general health may be. The reaction is too sudden and severe.[1]

In contrast, it has been maintained by Mr. Denis A. Hayes, president of the Glass Bottle Blowers' Association of America, in an address before the American Academy of Political and Social Science, May, 1906, that—

> It has been the common belief for years that glass blowing is an unhealthy occupation. Some insurance companies discriminate against the workers in this industry, but their action is based more upon suspicion than facts, because I doubt if glass blowing, so far as the work itself is concerned, is any more injurious than many other indoor occupations. There are, however, conditions which surround the work that are a menace to health and long life, but these unfavorable conditions can be and are being removed.[2]

Of interest also is the statement by Mr. Hayes that—

> The sudden changes in temperature experienced by men in this condition may be resisted while youth and vigor remain, but, owing to the early age at which they go to work, their strength and vitality are not given a chance to fully develop or are almost entirely destroyed at an age when other men are entering the prime of life. Being deprived of schooling they can have very little knowledge of hygienic rules or laws, hence do not sufficiently know how to protect themselves against the conditions here described. The result is that early in life they become victims of rheumatism, catarrh, throat troubles, and tuberculosis. The latter disease especially is most dreaded by our members.[2]

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[1] Report of U. S. Commissioner of Labor on Woman and Child Wage Earners in the United States, Vol. III, Glass Industry, pp. 254, 255.

[2] Idem, p. 257.

According to German observations by Dr. C. F. Schmidt, contributed originally to Weyl's Handbook of Occupational Hygiene, but translated for the report of the Commissioner of Labor on the glass industry, 1911, it is stated that—

> As a rule, glass blowers are people of stalwart frame. Some have a pale but many a ruddy complexion, caused by the intense heat. They are generally spare, for they are obliged to undergo great physical exertion, and, in consequence of this exertion and the great heat, they perspire freely. The constant exercise makes the muscular development of the upper part of the body, especially the arms, exceptionally powerful, while they are sometimes observed to be bow-legged on account of continual standing.[1]
>
> As glass blowers are forced to work in an atmosphere of a high temperature and are constantly exposed to the cool draft which rushes in through the open door of the factory, they are predisposed to colds. On one hand there are rheumatic inflammations, on the other catarrhal diseases of the bronchial tubes and of the lungs from which they suffer. Smoke often tends to produce bronchial catarrh, especially in the older factories where it is occasionally driven by unfavorable winds, directly from the openings of the furnaces, all through the factory. Since acute catarrhs of the larynx and bronchial tubes are often repeated, chronic bronchitis occasionally supervenes, from which pulmonary tuberculosis sometimes results.[2]
>
> It was formerly believed that glass blowers often contracted emphysema of the lungs, and theoretically this seemed quite probable, since they are obliged continually to inhale a great volume of air and then by forced expiration to drive it out through the contracted glottis, by which means great demands are made upon the elasticity of the lungs. This opinion was refuted by Prettin and Leibkind. They examined 230 blowers from different glass factories who had followed this occupation for at least 10 years. Two hundred and eighteen of them were from 25 to 50 years of age, and 12 were from 51 to 62. One hundred and two had been blowing glass more than 10 years, and an equal number more than 20 years. Among the blowers under 40 years of age practically no emphysema was found. Of 54 blowers from 40 to 50 years old, only 2 had emphysema in a slight degree. Among the 12 oldest, there were but 3 cases of severe emphysema of the lungs. Of the 230 blowers, therefore, only 5 in all had emphysema, and even with these it was doubtful whether the emphysema was superinduced by the blowing or by other diseases of the lungs. But it was demonstrated by spirometric tests that the vital capacity of glass blowers' lungs is very large, for the spirometer indicated an average amounting to 3,350 cubic centimeters (183.25 cubic inches.)[2]

PREDISPOSITION TO PULMONARY TUBERCULOSIS.

All of these observations reemphasize the earlier conclusion that glass blowers unquestionably are subject to an excessive mortality from pulmonary tuberculosis, largely in consequence of the continued and considerable inhalation of mineral dust. It is, therefore, of special importance that any and all measures concerning dust prevention should receive sufficient consideration, and that, as far as practicable, they should be adopted. With special reference to the possibilities of sanitary and other improvements, it is suggested by Dr. Schmidt that—

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[1] Report of U. S. Commissioner of Labor on Woman and Child Wage Earners in the United States, Vol. III, Glass Industry, p. 265.

[2] Idem, p. 267.

> Since it has been demonstrated that pulmonary emphysema is not due to blowing, except in very rare instances, the necessity for a mechanical blower no longer appears so urgently requisite as it was formerly assumed to be. An apparatus has been invented by means of which glass masses are blown into shapes required by compressed air. By the use of this contrivance not only might the need of strenuous exertion in blowing be obviated, but the danger of syphilitic infection and of the transmission of tuberculosis might also be removed. But in most of the factories the pipe continues to be used, because, it is claimed, the inflation by this method is more uniform. The transmission of syphilis may be prevented by a simple device, namely, by the use of an individual mouthpiece for every blower. But this method is opposed by the blowers because by its employment they are hindered in their work. Regular examinations are also recommended, but the workmen rebel against such inquisitorial regulations. The attempt has been made to reduce the intense heat radiation by placing asbestos-coated iron curtains in front of the ovens. These curtains are raised by a lever so arranged as to be automatically set in motion by the weight of the workman's body. For lowering the temperature revolving fans have also been installed in proximity to the working place. These create an artificial breeze to cool the workmen. Blue or gray panes of glass placed before the openings of the furnace serve as a protection for the eyes.[1]

POSSIBILITIES OF DUST PREVENTION.

Finally, on the question of the prevention of dust, it is said:

> The prevention of dust presents the greatest difficulties, though a large part of it is held captive by means of water. In polishing with the sand blast the sand is so drawn up by the agency of a suction appliance devised by Gutmann that no dust can escape. The dangerous explosions of lamp cylinders are now prevented in a glass factory at Weisswasser by a mechanical apparatus by which the cylinder is heated in a narrow zone throughout its entire circumference, and then by a light blow with a sharp instrument it is cracked off. But in the grinding department even the simplest protective arrangements are often wanting, or are not employed because the work is retarded by them. Above all, sufficient ventilation should be provided for, and a scrupulous daily cleansing of the grinding rooms. In every room, too, there should be an adequate supply of cuspidors. By systematic instruction of the grinders the danger of tubercular infection may be minimized. Personal hygiene

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[1] Report of U. S. Commissioner of Labor on Woman and Child Wage Earners in the United States, Vol. III, Glass Industry, p. 270.

would be promoted by the installation of bathrooms in the factories; and, in addition, good drinking water should be supplied.[1]

Most of the methods of dust prevention and other sanitary improvements are practical, if not in their entirety at least in part, and suggestive of much more extensive consideration in this country than has, heretofore, been the case.

MECHANICAL GLASS BLOWING AND PRESSING.

Glass blowing and pressing by means of mechanical devices are of comparatively recent introduction. Entirely automatic bottle-blowing processes date from 1898, and the work in connection therewith practically dispenses with glass blowing in the generally accepted sense of the term. Such processes, however, are quite frequently carried on in conjunction with typical methods of glass blowing and related operations, so that in a general way the occupational hazards have remained much the same. There are no vital statistics of mechanical glass blowers and pressers, but it is quite probable that when carried on under proper sanitary supervision the use of machinery may prove distinctly advantageous to health and longevity. The blowing of window glass by machinery is of much more recent introduction and the process thus far has not become extensively developed. (See Scientific American, July 19, 1913.) Glass-making machines are of three important types, as described in the Report of the Bureau of Labor on the Condition of Women and Child Wage Earners in the United States, with special reference to the glass industry (Washington, 1911). The first type is the press machine, the second the blow machine, and the third the automatic machine which improves upon the simple blowing machine by using a self-feeding and self-pressing device. In all of these processes human labor is to a considerable extent dispensed with and no skilled glass workers are required, since machinists, in a restricted sense of the term, are sufficient for the purpose. One advantage of the automatic machine is that it tends greatly, according to the report referred to, to reduce the number of boys employed, and it tends further to raise the age of the boys that are employed, and older boys are usually preferred.

No statistical information is available as regards the possibly beneficial results to health in consequence of the universal use of glass-making machines and the practical elimination of glass blowing by hand. It, however, would seem to be a safe inference that in the absence of thoroughly efficient methods of sanitary supervision and control, with special reference to the dust hazard, the specific liability to pulmonary tuberculosis in the glass industry is not likely to be materially reduced as the result of the extensive and even universal introduction of glass-making machinery.

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[1] Report of U. S. Commissioner of Labor on Woman and Child Wage Earners in the United States, Vol. III, Glass Industry, pp. 270, 271.

DIAMOND CUTTERS.

Diamond cutting, although an employment of rather limited extent in the United States, is of interest and importance as an occupation with exposure to mineral dust. Hand cutting is very rare and machine cutting is at the present time the general rule in the trade, as carried on under American conditions. There has been a decided improvement in labor conditions as the result of the active efforts of the Diamond Polishers' Union, which has a membership of about 400 in New York City alone. The occupation has the advantage of being well paid, at least in many individual instances, and some of the cutters are reported to receive as much as $80 and polishers as much as $60 a week.

PROCESSES OF MANUFACTURE.

The process of diamond cutting and polishing consists of two parts. After the stone has been cut it is taken to the polishing rooms, where the setter selects a suitable sized brass cup, called a dope, fills it with a mixture of lead and tin, and melts it in a gas flame. After working the solder to its proper shape, he places the diamond in the center, leaving only a very small part exposed. A mark is made on the solder before it becomes fairly set, and then the stone is passed on to the polisher. By the mark made on the solder the latter knows at once the exact run of the grain and the way it will polish to the best advantage. The polisher uses a circular disk composed of very porous iron, so that as the diamond is polished away in the form of dust it enters the pores of the iron, the result being that diamond cuts diamond.

According to Hirt, the first part of the process is exceedingly unhealthful. The bent position of the workman, the heat, and the danger of lead poisoning all contribute to make the occupation an unhealthful one. The principal bad features of the second part of the process are the dust inhalation and the straining of the eyes. While very little dust escapes into the air, the little, according to Hirt, is very bad in its effects, as the particles are angular, sharp, and, of course, very hard.

MORBIDITY OF DIAMOND CUTTERS AND POLISHERS.

Arlidge in his observations upon the diamond cutters' trade remarks, however, that—

> From our own observation of diamond cutting and polishing we can scarcely imagine any definite morbid result from the dust of the gem. It is far too precious to fritter away into dust by any coarse

grinding likely to give off a tangible quantity of this substance, and we suspect that the recorded ill health of diamond workers is chiefly attributable to accidental circumstances connected with the charcoal furnaces formerly used; to overheated and badly ventilated workshops; and to dissipated habits among the employees. So far as diamond dust may possibly be thrown off in the polishing process, so far, doubtless, would it be an irritant to the respiratory organs by reason of the very sharp and angular character of its atoms.

Tracy comments upon the sanitary aspects of the employment as follows:

> In diamond cutting the amount of dust created is small, and yet the occupation is a very injurious one. The "setter" prepares the diamond for the cutter by soldering it on the end of a copper rod with an alloy of 4 parts lead to 1 of tin. He does this with a charcoal fire, and is exposed to great heat, as well as to poisonous gases. The setters suffer from headache, tinnitus aurium, impaired digestion, and irregularity of the bowels. In Coster's factory, at Amsterdam, 73½ per cent of them were pale and emaciated, 57 per cent had palpitation, giddiness, præcordial distress, 56 chronic headache, 36 asthma, etc. The use of solder produces lead poisoning. Out of 90 examined, 30 showed traces of poisoning. In general, they are all sick men, and suffer from lung troubles. Nine per cent had phthisis. The cutters or polishers grind the gems on iron wheels covered with diamond dust and oil. The dust inhaled by them, though small in quantity, is enough to cause frequent chronic lung troubles. In Coster's factory, 52 per cent of them were thin and pale, 40 per cent asthmatic, 33.75 per cent suffered from headaches, etc.

HEALTH-INJURIOUS RESULTS OF DIAMOND CUTTING.

The extensive development of the diamond industry in Holland, chiefly in Amsterdam, has been reported upon by United States Consul Frank W. Mahin, who points out that there are some 70 establishments in Amsterdam which cut and polish diamonds and employ more than 10,000 work people, of whom about 1,700 are cleavers and cutters and 4,700 polishers, the remainder being engaged about the offices and in other work. He explains the occupational process, in part, as follows:

> Cleavers split the diamonds; cutters take off the rough and sharp edges and corners and make the general shape of the stone; polishers polish the stones and make their facets; turners turn the diamonds around in the apparatus which holds them, so that the facets can be made, every diamond worked in a first-class manner having from 58 to 64 facets; sawers saw stones which can not be cloven or which it is more profitable to saw; sometimes a stone is cleft and the parts are then sawed, but very small stones can not be sawed.

A more extensive technical account of the Amsterdam diamond industry has been contributed by Sir Thomas Oliver, in his report on Industrial Lead Poisoning, published by the United States Bureau of Labor Statistics (Bulletin 95), Washington, 1911. Upon the basis of his personal investigation he states that he found the workrooms overheated, owing to the large number of gas jets in use, and that the rooms generally were badly ventilated. "Work under these circumstances," he observes, "creates on the part of those following it an oversensitiveness to changes of temperature and a diminishing resistance to colds." Aside from a serious liability to lead poisoning, Sir Thomas Oliver's investigation failed to establish a special predisposition or liability to pulmonary tuberculosis. The occupation, however, has not been sufficiently investigated, but there are convincing reasons for believing that the dust factor in diamond cutting and polishing is of sufficient importance to prove inimical to health. Unquestionably important variations in liability are met with in the five principal groups of employment, viz, cleavers, polishers, turners, cutters, and sawers. Eyestrain is an important factor, and to the extent that any disease or physical disability tends to undermine health generally and reduces vital resistance. This factor, together with the liability to lead poisoning, is deserving of serious consideration. Although quite extensively developed in this country, chiefly through American branches of Amsterdam firms, there are no American vital statistics of this occupation, which, however, for the reasons stated, seems to require inclusion among unhealthy trades in which the mortality from pulmonary tuberculosis is quite probably above the normal.

GENERAL CONCLUSIONS.

Diamond cutting is briefly referred to in Kober and Hanson's Diseases of Occupation and Vocational Hygiene, but chiefly with reference to the risk of lead poisoning. On account of the European war the industry has been quite extensively developed in the United States, and, according to the Scientific American Supplement (Oct. 7, 1916), New York instead of Amsterdam is now the center of the diamond industry. In a descriptive account of diamond-cutting methods in the article referred to it is said that in the process of cutting about 60 per cent of the weight of the rough stone is lost, but as far as practicable "every particle of waste material from the splitting and sawing of the stone is carefully saved for use in the sawing and other subsequent operations." This, of course, implies the possibility of a fair degree of diamond dust intermixture with the general atmosphere and the consequential mechanical injury to the lungs on account of the inhalation of the diamond-dust particles. It is suggested in this connection by Kober that "all polishing processes should be carried on by the wet process and guarded by hoods and efficient exhaust ventilation." Aside from necessary safeguards against lead poisoning, Kober recommends attention to general ventilation, adjustable workbenches, and improved working conditions as regards light, air, space, and heating. In the absence of more conclusive evidence, it is not apparent that the diamond-cutting industry as carried on in this country under modern conditions is distinctly injurious to health, or that it seriously predisposes to pulmonary tuberculosis, on account of the special liability to the risk of mineral and metallic dust inhalation.

CHAPTER IV.—THE MINERAL INDUSTRIES (MINES, QUARRIES, ORE REDUCTION, AND SMELTING).

The mineral industries of the United States are of such enormous extent and variety that an adequate consideration of the health and mortality of the large number of persons employed therein would extend far beyond the scope of the present discussion of the mortality from respiratory diseases in dusty trades. In 1914 the approximate value of the mineral product of the United States, including both metallic and nonmetallic resources, exceeded $2,115,000,000, and the number of persons employed in the different branches of the industry was in excess of 1,000,000. An almost infinite variety of products are mined, quarried, and subjected to ore dressing, smelting and refining processes equally varied and complicated in extent. Table 121 illustrates the principal divisions or main branches of the mineral industry, and for the group of persons employed in metal mining, in addition, the number and proportion of persons employed underground. The table has been derived from Technical Paper No. 129 of the United States Bureau of Mines.

TABLE 121.—NUMBER OF PERSONS EMPLOYED IN MINERAL INDUSTRIES OF THE UNITED STATES, IN 1914.

Kind of mine, etc.	Total employed.	Number employed underground.	Per cent employed underground.
Coal mines	763,185	639,334	83.8
Copper mines	44,686	31,265	70.0
Gold and miscellaneous metal mines	48,438	35,432	73.1
Iron mines	44,807	24,847	55.5
Lead and zinc mines[1]	10,935	7,609	69.6
Miscellaneous mineral mines	9,249	2,465	26.7
Total, mines	921,300	740,952	80.4
Quarrying	87,936		
Coke ovens	22,313		
Smelting	26,960		
Ore dressing	14,501		

[1] Mississippi Valley only.

VARIED CONDITIONS OF EMPLOYMENT.

All general conclusions applicable to an industry of such varied extent must necessarily be of limited scientific value. Even with reference to well-defined groups, such as the subdivision of metal mining, or the broad division of coal mining into anthracite and bituminous, general conclusions must fall short of the required degree of scientific exactitude. As shown by the table, the proportion of men employed underground attains to 70 per cent in copper mining, while in iron mining the corresponding proportion is only 55.5 per cent. In the latter the process of open-cut mining or what is called stripping is quite generally employed. To a lesser extent, a similar method is employed in copper mining in the States of Utah and Nevada. Obviously, underground employment must by its nature be less healthy and predispose more to pulmonary tuberculosis than employment in the open, especially when carried on in connection with more or less health-injurious processes such as drilling, the use of pneumatic tools, etc. The number of specific employments in mines is much larger than is generally assumed to be the case, and the general use of the term " miners " in vital statistics is, broadly speaking, quite seriously misleading. Also the proportion of " miners " in the strict sense of the term varies considerably, according to the metal or mineral mined, and the term itself is becoming obsolete on account of the extensive use of machinery, rock drills, etc., by means of which the old-time pick and shovel miner has been replaced by machine miners, rock drillers, etc.

LIMITATIONS OF OCCUPATIONAL STATISTICS.

Much has been written in general terms on the health of miners and other mine employees which, for the reasons stated, requires to be accepted with extreme caution. No very satisfactory progress has been made in the perfection of vital statistics to the extent that the relative health and mortality of specific employments under and above ground can be ascertained, especially with regard to the relative incidence of pulmonary tuberculosis and nontuberculous respiratory diseases. As elsewhere pointed out, the health-injurious conditions are frequently limited to a comparatively small group of underground employees, as best emphasized in the case of the rock drillers in the gold mines of the Transvaal. All general conclusions, therefore, understate the true liability of the persons directly employed in the most health-injurious occupations in the mining industry and all broad conclusions concerning the relation of the industry in its entirety or its principal branches must be considered inadequate for medical and public-health purposes, or as a basic consideration for protective labor legislation. The generally accepted official statistics on the health of mine employees relate to the main branches of the mining industry of the United Kingdom. Much useful, and, in a measure, even more conclusive information is available, in part, for the mines and other mineral industries of the European continent, South Africa, and the several States of the Australian Commonwealth, but nearly all of the available data at the present time have reference to the mining industry as a whole and not, as the usual titles of the official tables would imply, to "miners" within the more restricted sense of the term.

COMPARATIVE MORTALITY OF ENGLISH MINERS.

The most recent English statistics, for the years 1900–1902, assign to certain branches of the mining industry a relatively favorable position in comparison with other more or less unhealthful occupations, chiefly with reference to dust exposure, as shown by the table following, derived from the Supplement to the 65th Report of the registrar general for England and Wales (London, 1908):

TABLE 122.—COMPARATIVE OCCUPATION MORTALITY STATISTICS, ENGLAND AND WALES, 1900 TO 1902.

[Data are for both occupied and retired.]

Occupation.	Phthisis and diseases of the respiratory system.		Phthisis.	Diseases of the respiratory system.	Diseases of the circulatory system.
	Mortality figure.	Ratio.	Mortality figure.		
Agriculturist	**171**	**100**	**85**	**86**	**96**
Ironstone miner	266	156	126	140	94
Carpenter, joiner	276	161	150	126	120
Coal miner	285	167	89	196	134
Wool, worsted—manufacturer	320	187	159	161	164
Baker, confectioner	327	191	165	162	131
Miller, cereal food manufacturer	331	194	129	202	143
Blacksmith, striker	332	194	158	174	149
Gas works service	355	208	141	214	128
Carpet, rug, felt—manufacturer	359	210	180	179	161
Bricklayer, mason, builder	377	220	194	183	129
Rope, twine, cord—maker	381	223	207	174	137
Cycle and motor manufacturer	381	223	217	164	102
Stone, slate—quarrier	396	232	190	206	123
Tinplate manufacturer, tinplate goods maker	410	240	221	189	142
Chemical manufacturer	415	243	98	317	162
Cotton manufacturer	422	247	197	225	170
India rubber, gutta percha—worker; waterproof goods maker	427	250	244	183	123
Zinc—manufacturer, worker	456	267	224	232	45
Lead manufacturer, leaden goods maker	474	277	165	309	224
Coal heaver	496	290	213	283	184
Gunsmith	498	291	244	254	151
Brass, bronze—manufacturer, founder, finisher, worker	500	292	272	228	161
Nail, anchor, chain, and other iron and steel manufacturers	503	294	187	316	173
Wood turner, cooper, etc	504	295	271	233	152
Copper—manufacturer, worker; coppersmith	519	304	162	357	139
Furrier, skinner	533	312	316	217	205
Glass manufacturer	551	322	283	268	177
Chimney sweep	556	325	284	272	153
Lead miner	598	350	324	274	162
Brush, broom—maker; hair, bristle—worker	609	356	325	284	173
File maker	712	416	387	325	198
Potter; earthenware, etc., manufacturer	758	443	285	473	219
Cutler; scissors maker	848	496	533	315	215
Copper miner	1,321	773	574	747	34
Tin miner	1,557	911	816	741	154

RELATIVE FREQUENCY OF TUBERCULOUS AND NONTUBERCULOUS RESPIRATORY DISEASES.

Table 122 is limited to the mortality from phthisis, diseases of the respiratory system, and diseases of the circulatory system. The table presents a curious contrast in liability to phthisis and diseases of the respiratory system combined, for iron miners exhibit, relatively, the lowest mortality in the group, while copper and tin miners show the highest. Compared with the agriculturist, those employed in the mining industries show a distinctly excessive mortality from phthisis and diseases of the respiratory system considered as a group. Coal miners, however, exhibit a relatively favorable mortality from phthisis but a decidedly excessive mortality from nontuberculous respiratory diseases. As observed in the report referred to, with regard to the causes of death, "there is no question that as compared with the past, an increasing proportion of such deaths are referred to their true causes; but what of the very large number still returned as 'abscess of the lungs,' 'congestion of the lungs,' 'pleurisy,' 'hæmoptysis,' and from other lung diseases more or less indefinitely described?" It is explained in this connection that on the basis of supplementary inquiries, "a considerable number of the deaths so returned were ascertained to be tuberculous in origin, although the original certificates had contained no intimation to that effect." This factor of probable error, however, is for the present purpose not of serious importance, although no satisfactory explanation has been forthcoming as to the reasons for the distinctly higher mortality from bronchitis in England and Wales in comparison with the United States, which may possibly be of even more importance in the case of the obviously dusty trades. The high degree of frequency occurrence of nontuberculous respiratory diseases in the mineral industry has also not thus far received the required specialized medical consideration, except in so far as each and every important group of respiratory affections has been brought into precise correlation to recognized health-injurious processes in the Milroy lectures by Dr. Edgar L. Collis on "Industrial Pneumoconioses, with special reference to dust phthisis."[1] In the observations on this important hygienic aspect of the mineral industries it is said in the report of the registrar general, with special reference to the preceding table, that—

> At the bottom of the list there are five industries, viz., filemakers, potters, cutlers, copper and tin miners, in which the combined mortality from phthisis and respiratory diseases (pulmonary disease) is

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[1] These lectures have been reprinted in their entirety in "Public Health," the journal of the Society of Medical Officers of Health, London, 1915, issues of August, September, October, and November. The lectures includes illustrations, microphotographs, etc.

from four times to nearly ten times as high as that of agriculturists. How much of this excess is due to the presence of dust in the atmosphere, and how much to other unhealthy conditions of work it is at present impossible to determine. The circumstance is, however, noteworthy that in 1890–1892 also these industries had occupied almost equally unfavorable positions in the scale of dust-producing occupations. Among the remaining industries in the present list ironstone miners, carpenters, and coal miners appear to suffer least severely from "pulmonary disease," their mortality figure exceeding the standard for agriculturists by not more than from 56 to 67 per cent. The list contains 18 occupations (9 of which are among the least healthy of the series) in which the workers experience a higher mortality from phthisis than from other diseases of the lungs. Among agriculturists the mortality from phthisis is practically the same in amount as that from respiratory diseases, and among all occupied and retired males the excess of phthisis over respiratory mortality is only 6 per cent. In some of the 18 occupations referred to the difference between the mortality from these two causes is small, but among others it is much greater than among occupied and retired males generally, amounting in the case of cutlers to no less than 69 per cent. The list also contains 17 occupations in which the opposite is the case. In the latter category the most conspicuous instances are copper miners, potters, copper workers, iron and steel manufacturers, coal heavers, lead manufacturers, chemical manufacturers, millers, and coal miners, in all of which instances the workers die from nontuberculous disease of the lungs much faster than they do from phthisis.

These conclusions are in conformity to a considerable amount of trustworthy medical and other evidence suggestive of the practical importance and, in fact, urgent economic necessity of more qualified medical consideration of the incidence of nontuberculous respiratory diseases in the mineral industry. On this account it has seemed advisable for the present purpose to enlarge somewhat upon the mortality and morbidity aspects of the mineral industries, even though the large proportion of the so-called "pulmonary" diseases of miners and stone workers are in all probability nontuberculous.

THE MINING INDUSTRY.

The health hazards of mining have for many years been the subject of scientific investigation in this and other countries. The extremely complex character of the industry, however, precludes the general application of many of the conclusions arrived at. For self-evident reasons, the more obvious accident hazards have, from the outset of mining operations, received more extended and technically qualified consideration. The deadly nature of many mine gases, aside from the risk of gas explosions, was made the subject of a scientific report as early as 1716, by Friedrich Hoffman and a rejoinder by Friedrich Andreae, amplified by medical and sanitary observations of value even at the present time.[1] During the intervening 200 years the mining industry has attained to truly enormous and world-wide importance, with a constantly increasing number of employees, either directly engaged in mineral production or in the subsequent conversion of metallic and nonmetallic substances. The progress which has been made in the scientific understanding of mining hazards to health and life is best emphasized in the most modern treatise on "Gas Poisoning in Mining and Other Industries," by John Blaister, M. D., and David Dale Logan, M. D., and the elaborate joint report of the Miners' Phthisis Prevention Committee of the Union of South Africa. It would be quite impracticable for the present purpose to discuss with the required brevity and sufficient thoroughness even the more important branches of the mining industry in their relation to health and mortality. The subject divides itself primarily into the mining of metallic and nonmetallic products, and is further subdivided according to essential variations in underground conditions, the mechanical and chemical properties of dust and gas exposure, methods of mining, and the use of safety precautions, chiefly in the direction of effective dust laying and the required use of respirators, particularly in dusty stopes. The predominating accident hazard, involving a considerable loss of life at the younger ages, materially impairs general conclusions regarding disease liability, since the effect of health-injurious conditions is obviously obscured by premature death in consequence of mine explosions, falls of roof, etc. During the year 1915 the fatality rate in American coal mines was 4.44 per thousand 300-day workers and in metal mines 3.89. Since the average age at death of mine employees in this country is approximately 32 years, the effect of such a fatality rate is to disturb seriously the proportionate mortality distribution from pulmonary tuberculosis and related diseases. The true menace of the dust hazard in mining operations subject to a considerable and continuous degree of dust inhalation is measurable only to an approximate degree, on account of the coincident and often more important mechanical accident hazard, which even far-reaching safety measures and precautions have not as yet reduced to relatively unimportant numerical proportion. The specific dust hazard in mining is much more serious in metal mining than in coal mining in that in the former the nature of the rock or gangue inclosing or containing the ore bodies is of decidedly greater hygienic importance than the metal dust when extracted by ordinary mining methods, or subsequently by processes of ore reduction, smelting, cyaniding, chlorination, etc. The hygiene of metal mining is, therefore, chiefly concerned with underground mining methods, which by their nature must be more unhealthful than open-cut excavations and quarrying, which, aside from other hygienic advantages, have the dust hazard in relation to health generally much reduced. The accident hazard in quarrying is also of lesser importance, and during 1915 the fatality rate was only 1.80 per thousand 300-day workers, against an average of 2.19 for the five-year period 1911–1915.[1]

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[1] See "Friedrich Hoffmann über das Kohlenoxydgas," by Dr. Albert Neuburger; Leipzig, 1912. Also of interest and value in this connection is the treatise, in German, by Dr. Theodore Poleck, Berlin, 1867, entitled, "Die chemische Natur der Minengase und ihre Beziehung zur Minenkrankheit."

The American mines and quarries, according to the returns of the United States Bureau of Mines for the year 1915, gave employment to 986,866 persons, of whom 734,008 were employed in coal mines, 152,118 in metal mines, and 100,740 in quarries. In addition thereto, in connection with metal mines and metallurgical plants, during the year 1915 the number of men employed was 18,564 at mills and ore-reduction works and 31,327 at smelters, etc. Of the workers in metal mines, during 1915, the number employed in copper mining was 47,174, in iron mining 39,391, in lead and zinc mining (Mississippi Valley only) 12,977, in gold, silver, and miscellaneous metal mining 45,312, and in the mining of nonmetallic minerals, 7,264. Regardless of the magnitude and nation-wide importance of the American mining industry, the available information regarding the health and disease liability of miners and the sanitary conditions of mines and mining communities is of a nature far from conforming to existing scientific and practical requirements. The most conclusive information regarding mining hazards in their relation to health, aside from the valuable and extended observations on miners' phthisis contained in the report of the interdepartmental committee on industrial diseases, is derived from British parliamentary reports, commencing with the classical investigations of the commissioners appointed to inquire into the condition of all mines in Great Britain, with reference to the health and safety of persons employed in such mines, issued in 1864, and the recent reports of a royal commission on metalliferous mines.[2] The results of these investigations amplify the scientific observations on "The Hygiene of Men Employed in Mines and Metallurgical Establishments," by Fuller, Meissner, and Saeger (Jena, 1895). Mining conditions and methods in this country, however, in fundamental essentials are so much at variance with those of Great Britain and the Continent of Europe that the subject requires to be investigated and reported upon in full detail in conformity to modern methods of scientific research. Our methods of shaft work, of driving adits and drifts, of stoping and rock drilling, ventilation, and the use of compressed air are sufficiently at variance with corresponding conditions and methods in other countries to require extended study for the purpose of ascertaining and determining the precise circumstances related to mining methods more or less injurious to health and life. Even the elementary considerations are far from having been thoroughly defined and become sufficiently well understood to eliminate the serious risk of inexperience with possibly disastrous results. In gold and silver mining, for illustration, the predominating metal in the United States is lead, which, because of its chemical qualities is hygienically of much greater importance than the precious metals, which are practically without pathological significance.[1]

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[1] United States Bureau of Mines, Technical Paper 165, p. 7.

[2] The following are some of the more important parliamentary publications which are indispensable to the student of the subject of mine hygiene and problems relative thereto:

Report of Commissioners on the Condition of Mines in Great Britain with Reference to the Health and Safety of the Miners; Evidence and Appendices, London, 1864.

Royal Commission on Mines; Reports, with Evidence, Appendices, and Index; 8 Parts; London, 1907–1910.

Reports of an Enquiry into the Ventilation of Coal Mines, etc., by John Cadman, D. Sc., F. G. S., and E. B. Whalley; London, 1909.

Royal Commission on Metalliferous Mines and Quarries; Minutes of Evidence with Index and Appendices; Volumes I–IV, London, 1912–1914.

Broadly speaking, all metal mining is essentially a process of rock extraction and the most important mechanical operation in modern mining consists of rock drilling, in connection with which vast quantities of more or less health-injurious dust are produced, the degree of injuriousness being dependent upon exceedingly important differences in the mechanical and chemical properties of the rock extracted. Variations in the type of drills, of which a large variety is in use, bear a direct relation not only to the quantity but also to the finely comminuted character of the dust created and the pathological consequences of continuous inhalation during the most active period of physical exertion in connection with mine work. These and other aspects of the metal mining and quarrying industry are emphasized in the general discussion of metallic and mineral dust, and particularly so in the separate consideration of the various branches of the stone industry, which, in broad outlines, as regards general conclusions, conforms to the more important special branches of mining. It, of course, is entirely immaterial for the present purpose whether the stone is quarried on account of its own intrinsic value and chiefly by blasting operations, or for the recovery of precious metals, chiefly by rock drilling and subsequent methods of ore reduction, smelting, cyaniding, etc. Quite different, of course, are the conclusions applicable to coal mining, where the product itself gives rise to an enormous amount of atmospheric pollution, which, however, in its effect upon the respiratory organs, with special reference to pulmonary tuberculosis, is apparently much less injurious than the corresponding degree of dust contamination resulting from underground mining processes for the recovery of copper, zinc, gold, and other ores. Quite different also are the conditions in quicksilver mining, although the rock formation, in a general way, may conform to the rock quarried and extracted by drilling processes and the use of explosive substances in the mining of gold, silver, copper, etc. Quicksilver in its natural state rarely permits of being mined without very serious consequences to the health of miners, so that preference, as a rule, is given to the mining of cinnabar ore, which does not become injurious to health until subjected to subsequent reduction and refining processes.

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[1] See Elements of Mining, by George J. Young; McGraw-Hill Book Co., New York, 1916.

In the hygiene of mining the dust problem is of fundamental importance, aside from the serious menace of finely comminuted coal dust as a cause of disastrous mine explosions. The health-injurious consequences of continuous and considerable rock dust inhalation are, fortunately, more generally recognized at the present time than in former years and reasonably effective methods are being made use of to reduce the dust hazard to a minimum. Since quartz dust is the most injurious form of dust exposure in deep mines, the pathological results of such exposure, as made evident by the increased frequency of miners' phthisis, have attracted most attention in South Africa, although correspondingly unsatisfactory conditions prevail in the deep mines of the central and western sections of the United States.[1]

GOLD MINING IN SOUTH AFRICA.

The most conspicuous health-injurious effects of metal mining occur in connection with mining methods which require the use of underground drills, by means of which the rock substances are reduced to a highly comminuted condition. When the rock dust consists of practically pure quartz, as is the case in the South African gold mines on the Rand, the damage done to the lung tissue is so serious that the resulting condition of lung fibrosis terminates fatally within a comparatively short period, though generally as an important result of a superinduced tuberculosis. The typical form of lung disease common to miners subjected to the conditions referred to is known as "miners' phthisis," and the disease as such has a literature of its own. Modern high-power drills operated by compressed air have enormously increased the relative degree of air pollution in metal mines to the extent that the use of dust-allaying methods has become imperative as a more or less effective means of reducing the consequent mortality and morbidity of the men employed. The effective spraying of dusty stopes is, however, frequently quite difficult if not impossible when vertical drilling is necessary and unavoidable. In all such operations the compulsory use of respirators seems preferable, since in the operation of the power drills the men expose the mouth and the nostrils directly to the continuous stream of minute particles of silicious dust which, as abundantly shown by autopsy records and experimental evidence, proves exceedingly injurious to lung tissue, with a resulting predisposition to pulmonary tuberculosis.

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[1] Of much practical value is the report of an Investigation at Bendigo into the Prevalence, Causes, and Prevention of Miners' Phthisis, and the Ventilation of the Bendigo Mines, by Walter Summons, M. D., Melbourne, 1907. See also, pp. 336–342.

MINERS' PHTHISIS IN SOUTH AFRICA.

Within recent years a number of important contributions have been made to the subject of miners' phthisis, chiefly the report of a commission appointed under the provisions of the miners' phthisis allowances act, to inquire into the prevalence of miners' phthisis and pulmonary tuberculosis within the Union of South Africa, Cape Town, 1912. The reference to the workmen's compensation act is particularly significant in that it emphasizes the practical importance which is now being attached to miners' phthisis, more or less directly attributable to the occupation exposing miners to inherent occupational-disease dangers underground. The miners' phthisis act of South Africa of 1912 ranks as an epoch-making document and deserves most thoughtful consideration as a measure called for by perhaps the most health-destructive conditions met with in any industry, trade, or occupation throughout the world. The act makes provision for persons who have contracted miners' phthisis; and there is a frank recognition of the fact that the disease results in consequence of the employment and that the same is specifically cognizable as an occupational disease, separate and distinct from pulmonary tuberculosis contracted outside of the occupation. Joint contributions of employers and employees are required to be made, so that the entire responsibility for the disease is not made a burden upon the mining industry, in view of the fact that unquestionably a fair proportion of the existing amount of tuberculosis among miners employed is not directly attributable to the employment. Section II of the act reads that the minister shall at the commencement of this act frame a list of mines in the Union wherein the mineral dust produced by mining operations is in his opinion of such a nature as to cause miners' phthisis, and he may from time to time add or withdraw the names of mines from such list. This, in other words, separates the exceptionally dusty mines with obvious conditions predisposing to pulmonary tuberculosis from the mines not subject to this hazard and therefore not liable to assessment on account of the miners' phthisis fund. Subsection II, of section 14, provides that any employer or any number of miners, not being less than one-third of the miners so employed in any mine, may likewise petition the minister on the ground of the improved health conditions of the mine to exclude or remove that mine from the said list, and the minister shall thereupon order such investigation as he may deem fit and as a result of such investigation he may, if he thinks fit, remove such mine from said list, or reduce the amount of contribution payable in respect to said mine. This important provision directly encourages the sanitary improvement of mines to the extent that on the basis of ascertained evidence a previously proscribed mine may thereafter be included among the working places considered relatively harmless as regards exposure to health injurious dust. The act in its entirety has been reprinted in the Bulletin No. 9 of the International Labor Office, London, 1914.

REPORT OF MINERS' PHTHISIS PREVENTION COMMITTEE.

The general report of the miners' phthisis prevention committee of the union of South Africa was published at Pretoria, under date of March 15, 1916. This report is unquestionably the most comprehensive and scientifically conclusive investigation of its kind ever made. The report includes a brief historical introduction, observations on the nature and general relations of miners' phthisis, a discussion of the principles of tuberculosis control, an outline of the general characteristics of the dust occurring in the silicotic lung, in mine air, and in streets, a descriptive account of the sampling of air and the determination of dust, a description of the principal operations giving rise to dust in mine air, amplified by methods of laying dust and preventing its formation or inhalation and the most suitable methods of laying dust produced by mine operation, including blasting, drilling, and transportation. In addition the report considers the problem of dust in crusher stations, the subject of ventilation, the drafting of model regulations, and the importance of a general survey of existing conditions more or less relating to health and longevity. The appendices to the report are exceptionally valuable and inclusive of practically every scientific aspect of mine sanitation and the related problem of dust control as a condition precedent to more or less effective methods of phthisis prevention. The statistical analysis of the returns from the miners' phthisis board by Dr. G. G. Maynard are most instructive and indicative of the broadening value of statistical methods in their practical application to sanitary and economic problems. The report and appendices constitute in a general way the scientific basis for similar investigations in every other country in which metal mining is an industry of relative importance.

MINERS' MORTALITY IN RHODESIA.

The continued seriousness of the situation in Rhodesia is emphasized by a statement in the annual report of the Rhodesia Chamber of Mines for 1915 that the mortality from disease among native laborers was 21.94 per 1,000, aside from a mortality from accidents of 4.19 per 1,000. In Rhodesia as well as on the Rand the mortality from pneumonia continues to form an excessive proportion of the mortality from all causes, and the disease has properly been made the subject of a memoir published by the South African Institute for Medical Research, entitled "An Enquiry into the Etiology, Manifestations, and Prevention of Pneumonia Amongst Natives on the Rand, Recruited from Tropical Areas," by G. D. Maynard, Johannesburg, 1913. The same subject was subsequently investigated by Major General W. C. Gorgas, M. D., United States Army, whose report constitutes a source of much useful information, emphasizing the great practical value of sanitary improvements outside of the mines as well as in the work places underground, and the relatively greater value of such improvements in the case of native laborers in tropical regions on the Witwatersrand. The mortality from disease among native laborers employed in the mines of the Rand in 1915 was 16.47 per 1,000. The lesser figure for the Rand is explained by the nonemployment of tropical natives in the Transvaal. The data are suggestive in that they emphasize the importance of the race factor in the use of comparative vital statistics. During 1915 there were 991 deaths from all causes among the natives employed in Southern Rhodesian mines, of which only 48 deaths were attributed to phthisis, while 442 were attributed to pneumonia, and 21 to other diseases of the chest. It is practically certain that, on account of the extremely dangerous nature of the dust exposure underground in Rhodesian mines, a case of lung fibrosis is usually fatal before there is time for the development of a subsequent true pulmonary tuberculosis.

PRACTICAL PREVENTIVE MEASURES.

Special and most commendable efforts have been made for a number of years by the mine owners of South Africa to control the problem of miners' phthisis through a miners' phthisis prevention committee, and good results have been achieved by means of dust-allaying methods which are deserving of much more consideration on the part of mine owners and managers in the United States than has thus far been the case. There has also been established a miners' phthisis sanatorium, with regard to which, during the month of September, 1915, a recommendation was made " That a separate institution should be provided for men suffering from tuberculosis plus silicosis, the present sanatorium being reserved for men suffering from silicosis only." It is in this direction of careful specialization that the best results are likely to be achieved in the course of time. The activities of the Transvaal miners' phthisis prevention committee are briefly reviewed in the Engineering and Mining Journal, June

17, 1916, with special reference to dust allaying. It is pointed out that blasting produces enormous quantities of dust and that much may be done to reduce the quantity produced by intelligent methods of supervision and control. It is conceded that the dust produced during blasting operations is very fine and most injurious and that "its inhalation should be avoided at any cost." It is agreed that machine drilling with water produces a smaller quantity of dangerous dust than blasting, but that the amount is still very large and is liable to be inhaled over a much longer period than air contaminated by blasting. It is, therefore, recommended that "by the use of water applied in a proper manner with suitable devices, the dangerous dust can be diminished to a small fraction of that produced when dry—in fact, to less than 1 per cent of the original quantity, when it is comparatively innocuous." Special emphasis is placed upon the imperative necessity of using proper devices for the allaying of the dust and the urgency of constant vigilance in their application, which, it may be said, is as yet inadequately recognized by mine managers and superintendents in this country. Attention is directed to a notice posted at all the Rand mines by the chamber of mines, reading in part as follows:

Effects of dust allaying on the number of dust particles breathed per minute.

	Millions of dust particles.
Blasting:	
Five minutes after blasting cut, no water spray [1]	2,450
After using water spray for 30 minutes in drive	10
Drilling with 3¼-inch piston drills:	
Collaring dry [1]	125
Collaring wet	57
Drilling dry [1]	330
Drilling with wet jet in hole	12
Watering with cup	28
Hammer drills without water feed:	
Collaring dry [1]	64
Collaring wet	8
Drilling dry [1]	18
Drilling with wet jet in hole	9
Hammer drills with efficient water feed:	
Collaring	3
Drilling	6
Crusher houses:	
Dusty conditions	31
Dust well laid	2
General:	
Dust-laden air entering drive after blasting	1,770
Mine air after standing over Sunday	4
Street dust (excluding visible) on a dusty day	2

(The figures given are the number of millions of particles of dust of 1/2000 of an inch and less in diameter breathed per minute.)

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[1] Work under these conditions is prohibited by law.

MINERS' PHTHISIS IN NEW SOUTH WALES.

One of the most important or scientifically conclusive investigations into the prevalence, nature, causes, and prevention of miners' phthisis was made in 1906 under the auspices of the Bendigo Hospital Committee and at the cost of the trustees of the Edward Wilson estate, by Walter Summons, M. D., including a report on the ventilation of the Bendigo mines. This investigation, following a fairly comprehensive statistical study, considers the symptoms, the pathology, the etiology, and the prognosis of miners' phthisis and the more obvious prophylactic measures, amplified by a brief summary and practical recommendations. The statistical investigation covers a period of 30 years and the statistical facts presented are of a sufficiently startling character to suggest the practical value of the inclusion of Table 123.

TABLE 123.—ANNUAL DEATHS AMONG BENDIGO MINERS, DETERMINED IN 5-YEAR PERIODS, AND ESTIMATED AS PER 10,000 LIVING AT ALL AGES.

Year.	Miners' phthisis (tuberculosis).	Chronic bronchitis.	Acute pneumonia.	Total lung diseases.	Fatal mining accidents.	All other causes.	Total deaths.
1875–1879	48.5	8.0	20.5	77.0	28.5	74.3	179.8
1880–1884	56.9	13.1	17.0	87.0	32.8	70.6	190.4
1885–1889	80.0	39.3	20.6	139.9	31.3	111.3	282.5
1890–1894	84.6	34.4	16.9	135.9	28.4	120.2	284.5
1895–1899	102.4	35.6	27.4	165.4	21.9	130.4	317.7
1900–1904	100.8	23.0	21.3	145.2	14.7	96.5	256.3
1905–1906(½)	129.6	34.6	27.4	191.6	9.2	69.2	270.0

The table indicates a very marked increase in the death rate from pulmonary diseases, especially tuberculosis, and largely subsequent to the year 1880, when the detrimental effects of machine drilling had become manifest. As observed in the report by Dr. Summons, "Since their coming into general use, the increase in the death rate has been progressive and during the last 18 months it has been so excessive that the outlook is indeed fraught with the gravest forebodings." The further conclusion is advanced that "The detrimental influence of quartz mining, though directly acting on a section of the adult males only, is felt by the whole community of the mining center," for, as brought out in the report, the death rate of Bendigo was twice the normal rate for the State of Victoria. An interesting comparison is made with the mortality from respiratory diseases in other countries and for more or less corresponding periods of time, as follows:

Comparative mortalities from respiratory diseases per 10,000 living.

	Rate.	
Adult, males, Victoria, 1903–1905:		
Phthisis	20.8	
Pneumonia	12.1	
Other respiratory diseases	10.0	
		42.9
Occupied males, England and Wales, 1890–1892		58.0

	Rate.	
Bendigo miners, 1905–1906 (½):		
Phthisis	129. 6	
Pneumonia	27. 4	
Bronchitis	34. 6	
		191. 6
Tin miners, Cornwall, 1900–1902		182. 0
Coal miners (England) 1890–1892		58. 0
Ironstone miners (England) 1890–1892		46. 0

According to the statement above the mortality from lung diseases of the quartz miners at Bendigo and of the tin miners at Cornwall is far in excess of the corresponding mortality, for illustration, of English coal and ironstone miners and the adult male population of the State of Victoria and England and Wales. In amplification of the general discussion the report includes an analysis in detail of 2,068 deaths of miners in the Bendigo district and of 750 miners in the Eaglehawk district. On account of its value, the table is included:

TABLE 124.—MORTALITY OF BENDIGO MINERS FROM JANUARY, 1875, TO JUNE, 1906.

	Number of deaths.	Per cent.
BENDIGO CITY (EXCLUSIVE OF EAGLEHAWK).		
Pulmonary diseases:		
Phthisis (tuberculous)	661	
Bronchitis	230	
Pneumonia	174	
Total	1,065	51.5
Nonpulmonary diseases:		
Cardiac disease	176	
Senility and asthenia	142	
Abdominal diseases	86	
Cancer	76	
Nervous disease	66	
Typhoid fever	64	
Vascular diseases	39	
Renal disease	37	
Diseases of urinary tracts	15	
Septic infections	15	
Rheumatism	6	
Hydatids	4	
Alcoholism	3	
Other diseases	25	
Total	754	36.5
Violent deaths:		
Fatal mining accidents	193	
Other accidents	41	
Suicides	15	
Total	249	12.0
Total, Bendigo City	2,068	100.0
EAGLEHAWK.		
Pulmonary diseases:		
Phthisis (tuberculous)	240	
Bronchitis	50	
Pneumonia	57	
Total	347	46.3
Nonpulmonary diseases (inclusive of accidental deaths other than those caused by mining)	316	42.1
Fatal mining accidents	87	11.6
Total, Eaglehawk	750	100.0
Total for district	2,818	

Aside from the statistical investigation, a fairly extensive amount of clinical material was subjected to qualified analysis. In the aggregate 192 cases, embracing all the stages of the disease, were considered. The details are given in full in the report for both tuberculous and nontuberculous cases. The results are summarized in the statement that—

> The clinical histories of the above and other cases show the disease is most insidious in its onset, and, as a rule, only after years of work do definite symptoms present themselves. By this time, however, damage to the lungs has taken place, and the condition is irremediable. The early symptoms are frequently recurring coughs and mild attacks of bronchitis, in which the ciliated epithelium of the bronchial tubes is destroyed, and thereby greater facilities are afforded for the absorption of the dust particles. The general health is good, or the feelings of malaise so slight as not to interfere with the men's capacity for work. The primary irritating cause continues, and the bronchial tubes are progressively more and more damaged. This condition may last for years, and the only symptoms are those of a frequently recurring or of a continuous bronchitis.
>
> The dust particles inhaled are, for the most part, caught in the mucus of the respiratory passages, and spat out again, giving rise to what is popularly called the "black spit." Even years subsequent to working underground, the expectoration may have at times a bluish black discoloration, especially when there is a caseation and necrosis of the lung tissue. Even without any infection with the tubercle bacillus, the expectoration may be profuse and muco-purulent in character, which, on microscopic examination, is found teeming with staphylococci and many putrefactive organisms. In other instances the dyspnoea may be extreme, but the patient has practically no spit, or some only first thing in the morning.
>
> Sooner or later, however, the miner notices he becomes more readily short of breath than formerly, especially so if he has any bronchitis; and this is characteristic of attacks of bronchitis to which the miners are liable—that they become much more dyspnoeic than ordinary patients with bronchitis. The breathlessness increases *pari passu* with the amount of harm done to the lung, till, finally, though constitutionally his health is good, the man is compelled to cease working; and at this stage, even while resting, there is wheezing with prolonged expirations, while on the slightest exertion there are marked stridor and hurried breathing. This dyspnoea is unassociated with any signs of cardiac incompetence, and, therefore, is purely respiratory. In no case was the interference with respiration so extreme as to cause cyanosis.

This rather technical explanation is an admirable contribution toward a more precise and conclusive definition of a case of pure fibrosis, as separate and distinct from a case of unquestionable tuberculous infection. The physical signs of the disease are frequently quite confused, but the chest expansion is generally below the average, for according to the investigation, "mensuration showed the average expansion in 30 cases to be 1½ inches, one inch or less being all some patients could manage." By auscultation, however, the greatest knowledge was gained of the lung condition, for according to Dr. Summons—

> The usual evidence of bronchitis, emphysema, and fibroid lung was universal, and, prior to the full development of these conditions, much alteration in the respiratory murmurs was noted, as diminution, prolongation of expiration, raised pitch, and different grades of bronchial breathing. Creaking sounds, perceptible both on inspiration and on expiration, and cardio-respiratory murmurs along the left cardiac border and in the region of the apex beat—notably a series of short puffs synchronous with the heart beat, and equally well heard on expiration as on inspiration, with crackles and fine pleural friction—in this region are common.

Irrespective of extreme care in physical examination, or on inspection, or by means of percussion and auscultation, or even the use of the fluorescent screen, the conclusion is reached by Dr. Summons that while the main symptoms are those of a chronic and obstinate bronchitis, "there are no distinctive signs by which one can say that this is a miner's lung, but all point to a chronic irritation of the lung and pleurae, and the results, in addition to being nonremedial, are, to a greater or less extent, steadily progressive."

The question is taken up as to the length of time in which these symptoms develop. It is stated that—

> As a rule men, when first taken on, are employed in shoveling and trucking, and it may be some years before the miner is promoted to work with a rock drill. The earlier work involves the inhaling of a certain quantity of dust, but to nothing like the extent that work with a machine in dry country rock does without the beneficial effect of a dust-laying water jet or spray. Under these circumstances a strong, healthy man, going home after his shift with merely a slight cough, may show no detrimental effect to his health for many years. Others, on the contrary, rapidly develop serious symptoms. All men, however, do not become victims. In one mine, for example, two men, aged 67 and 71 years, respectively, were found working as mates, and each did a fair day's work. They were not native born, and had not worked altogether in the Bendigo mines.

The value of an examination of the sputum is emphasized in the statement that while the physical signs in some cases were those only of a simple fibrosis, the sputum examination showed abundant bacilli. The symptoms are more or less at variance with those of ordinary phthisis, for it is said that—

> Haemoptysis is rare, but in one case it was the final ending. This may be understood when it is recognized that the dust irritation sets up a peribronchitis and a periarteritis at the same time, with the slow production of much fibrous tissue. With excavation of the lung these tough, fibrous cords resist the necrotic process, or they are destroyed so slowly that in nearly all cases the blood is clotted

and organized before the vessel wall is destroyed. The dyspnoea is, as would be expected, quite out of all proportion to the tuberculous involvement of the lung. This is even the case when there has been no evident respiratory embarrassment prior to the superadded tuberculous infection. Pneumothorax seems to be extremely uncommon. In many of the chests examined at autopsy it would be an impossible condition, as the pleural cavities were totally obliterated by adhesions.

The foregoing observations have been quoted at length in view of the increasing importance of concrete and conclusive diagnosis of miners' phthisis in States in which the principle of workmen's compensation on account of occupational injuries, in the broadest sense of the term, may be adopted. The most thorough inquiry in the State of Victoria found it extremely difficult to fix the onset of tuberculous infection. On the basis of 204 autopsies of cases of miners' phthisis, 95, or 47 per cent, of the cases presented abundant evidence of tuberculosis. It is pointed out that out of the difficulty to determine accurately the prevalence of tuberculosis several questions arise, and the question is asked, "Is there a type of case starting in the usual way, and progressing as a pure fibrosis, with recurring attacks of bronchitis and pleurisy, which, going on and on, finally brings about heart failure and death, without any superadded bacterial infection? And what is the cause of death in the lung diseases to which the miners are liable?"

In reply to the second question the conclusion is advanced that at the present time "all Bendigo miners dying of their respiratory diseases die of tuberculosis." This statement was based on the final ending of 27 almost consecutive cases. Reference is made to a report on miners' phthisis by the Transvaal Medical Society in 1903, according to which "It is not common to find the typical physical signs of tubercular phthisis present, and this observation, together with the confirmatory fact that out of a series of over 30 sputa from cases of disease of the lung of miners examined only two or three were found to contain tubercle bacilli, leads us to conclude that, while in some cases a true tubercular phthisis may coexist or may be superadded, the conjunction is only seen in a minority of cases."

An article by Sir Thomas Oliver in the British Medical Journal is referred to in the statement that "In some instances tubercle bacilli are detected, in others not at all. Since during life no tubercle bacilli are found in the expectoration, and after death none are found in the lungs, it is apparent that in Rand miners' phthisis we have an illustration of a true pneumoconiosis—that is, of a lung that has been irritated by dust, and in which, while the changes become progressive and ultimately lead to death, the malady from first to last can be nontuberculous."

Dr. J. S. Haldane's conclusion on the health of Cornish miners is quoted, however, to the effect that "We thus have, as the gross results of the investigation, that out of 23 cases 17 were definitely shown to be tubercular, and further analysis of the cases shows that in 12 cases a history of the men having worked machine drills was obtained and of these 8 were tubercular." Again, "9 of the men examined had worked in the Transvaal and of these 6 were tubercular." Dr. Summons therefore concludes that—

> The inference to draw from these almost contradictory opinions, and the evidence obtained from the cases at Bendigo, is that the tubercular infection depends entirely on local conditions. If the disease is rare in the community, the chance of infection is diminished, and vice versa. Every infected case, however, whether miner or nonminer, if his sputum contains bacilli, is a danger to others, and unless precautions are adopted the percentage of tubercular cases will increase.
>
> A useful clinical classification, therefore, is—
>
> (1) A pure fibrosis of the lungs, nontuberculous in origin, and which is a silicosis.
>
> (2) The mixed type, with a tuberculous infection in a fibroid lung.

As regards the pathology of miners' phthisis, the discussions by Dr. Summons are in a large measure based upon a number of exceptionally interesting autopsies and supplementary scientific research, summarized in the statement that—

> The essential pathology of miners' phthisis is thus seen to be a fibrosis of the lungs, with an associated chronic irritation of the bronchial tubes, consequent upon which coarse, emphysematous changes ensue, and sooner or later infection with the tubercle bacillus takes place, with the resulting formation of tubercles, caseation, and formation of cavities. The tuberculous process is altered somewhat from the fact that the tissue affected is not normal but fibrotic lung tissue.

The inorganic constituents of a Bendigo miner's lungs were examined by Mr. Gustav Ampt at the Melbourne University, with the following result:

TABLE 125.—ANALYSIS OF INORGANIC CONSTITUENTS OF A BENDIGO MINER'S LUNGS.

Constituent.	Weight (grammes).	Per cent of total ash.
Silica	5.3127	40.52
Alumina	4.3851	33.45
Ferric oxide	1.2914	9.85
Lime	.0471	.36
Magnesia	.1645	1.25
Phos. pentox	.4263	3.25
Constituents found	11.6271	88.68
Total ash	13.1101	....
NaCl, Na_2O, K_2O, SO_3, by difference	1.4830	11.32

Table 125 is briefly interpreted as follows:

The silica constituent of a Bendigo miner's lungs was 40.52 per cent of the total ash content, in contrast to the ash content of a normal lung given in the same report as only 13.4 per cent. It is explained in this connection that the lung analyzed was in but a moderately advanced stage of silicosis, but that the proportion of silica shows adequately the importance of the part it plays in the abnormal lung condition. The presence of alumina to the extent of 33.5 per cent of the ash content is equally abnormal and in large measure accounts for the fibrosis. The conclusion is therefore advanced by Dr. Summons that—

> Silica dust is therefore to be considered the cause of nontuberculous miners' phthisis. It is constantly found in their lung tissue, enveloped by fresh fibrous tissue formed in consequence of its presence; and, even after many years, presents the same appearance as when it was inhaled. On incineration it was regained from the lungs, and by chemical analysis shown to be of the same nature as the country rock of the Bendigo mines. Without the dust no lung disease is prevalent, hence it, and it alone, is the sole cause of miners' phthisis (nontuberculous), and it can safely be asserted that, with the absolute prevention of dust, the lung disease would almost cease to exist. The other sources of air vitiation, as noxious fumes, are adjuvant causes, but of themselves do not produce sufficient detriment to health to bring about lung disease.
>
> Miners' phthisis (nontuberculous) is thus a typical example of a disease brought about by the mechanical action only of dust particles, without absorption of them, and with no poisoning of the system generally. It is a disease of purely local origin, and continues as such till tuberculosis, with its specific bacillus, is superadded and poisons the body with its toxines, and, in addition, produces alteration in the nature of the pathological changes in the lungs.

OFFICIAL INVESTIGATIONS IN THE UNITED STATES AND NEW SOUTH WALES.

There has not, unfortunately, been a correspondingly clear and concise recognition of the dust hazard in the mining industries of this country, with the possible exception of the zinc and lead mines of southwestern Missouri, where the conditions have been subjected to a joint investigation on the part of the United States Bureau of Mines and the United States Public Health Service. An earlier official investigation in the State of Montana proved practically inconclusive, because of the nonuse of the required technical information. Most of the conclusions involved in a discussion of health hazard in mining represent scientific problems of an exceptionally complex nature, with reference to which experimental evidence is frequently of considerable practical value. Such investigations, for illustration, as have been made by Prof. Beattie, of Liverpool, upon the effects of stone dust, and with some reference to coal dust, prove the practical usefulness of research of this kind. The results of an exhaustive investigation into the health of metal miners are presented in the reports of the royal commission on metalliferous mines and quarries, presented to both Houses of Parliament during the years 1912–1914.[1]

An equally important official investigation was made during 1914 by the royal commission on the mining industry at Broken Hill, in the State of New South Wales, which includes important observations on improved methods of ventilation, the possibilities of temperature reductions in hot mines, etc. Another important investigation was made in 1910 by the royal commissioner of Western Australia on pulmonary diseases amongst miners, including a considerable amount of new evidence and some very interesting statistics on the frequency of lung diseases among miners and in the mining districts generally.[2]

ACCURACY OF DEATH CERTIFICATION.

All of the available evidence confirms earlier conclusions, based largely upon official mortality statistics and insurance experience, that the death rate of miners, considered as a group, is generally distinctly above the average, but that during recent years there has been a material improvement, particularly among coal miners in the principal coal-producing countries of the world. Practically all of the official investigations, however, have been limited to the general occupational aspects of the mining industry, and insufficient attention has been given to employments in detail, with the possible exception of the South African inquiries, in which rock drillers were differentiated from mine employees generally. The available evidence is more or less conflicting, particularly on account of the existing confusion in medical terminology. Death certificates are frequently filled out in a superficial manner and the diagnosis is rarely confirmed by autopsy findings. Extreme caution is therefore necessary in the interpretation of the statistical data, which, as a general rule, fail to differentiate the several important forms of respiratory diseases.

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[1] Royal Commission on Metalliferous Mines and Quarries; Vol. I. Minutes of evidence, London, 1912; Vol. II, Minutes of evidence. London, 1914; Vol. III, Minutes of evidence. London, 1914; Vol. IV. Second report, London, 1914.

[2] Report of the Royal Commission on the Mining Industry at Broken Hill, State of New South Wales, Sydney, 1914. This report and evidence makes a volume of nearly 900 pages and the evidence includes nearly 25,000 questions and answers. There has been no equally exhaustive investigation in any other country in which the metal-mining industry is of equal importance. The main questions considered are the reduction of the temperature in mine working to 75 degrees Fahrenheit, the compensation of mine employees in all cases of industrial sickness or accident. the improved ventilation of mines, the authorization of officials of industrial unions to visit the mines, the control of foreign immigration, and finally the best means of securing a diminution in the frequency of mine accidents. The title of the earlier investigation is "Report of the royal commission on pulmonary diseases amongst miners, together with appendices and minutes of evidence," published at Perth, Western Australia, October 4, 1910. This report includes the results obtained by the actual physical examination of working miners and a considerable amount of experimental and pathological evidence.

MINERS' PNEUMOCONIOSIS AND ANTHRACOSIS.

Under the general term "Pneumoconiosis" Sir Thomas Oliver, in Allbutt and Rolleston's System of Medicine, presents a most interesting discussion of miners' lung diseases, in which separate consideration is given to coal miners' phthisis or anthracosis, the diseases of metal miners, the lung diseases of slate quarriers and dressers, of those engaged in ganister mining and ganister crushing, and in slag crushing, and gold miners' phthisis, or silicosis, aside from the diseases incident to a number of related employments, such as millstone building and French buhrstone dressing, which also involve considerable and continuous exposure to health-injurious mineral dust. Concerning coal miners, Sir Thomas Oliver observes that the conditions under which the industry is carried on have so materially improved during recent years that the employment may now be considered a healthy occupation, and he states that coal miners, as a class, suffer less from phthisis than men in other occupations, and that coal miners' phthisis, or anthracosis, is on the decline in the United Kingdom. He observes that—

> Although colliers occasionally suffer from cough, shortness of breath, an abundant black and at times purulent expectoration, and show progressive emaciation, the lungs after death being found black and excavated, and on section exuding an inklike fluid on pressure, it is more than probable that, owing to the improved conditions of work in the mines, the disease is not a pure pneumoconiosis due to dust, but a mixed tuberculous malady, the bacillary infection of which has been caught not in the pit but in the home or elsewhere.

How far these conclusions apply to American coal miners has not been determined. The results of such investigations as have been made are inconclusive, and the evidence is generally of a superficial character. Nor are there reasons for believing that even in the United Kingdom coal miners suffer less from pulmonary tuberculosis than men employed in many other occupations, when the required correction is made for the determining influence of the liability to accidental death. The majority of coal miners' accidents occur at ages under 40, when the proportionate mortality from pulmonary tuberculosis in industrial employments is generally excessive. There are, however, no reasons for assuming that the frequency of pulmonary tuberculosis in coal mining is anywhere near as common as in metalliferous mines, in which it varies, of course, quite widely according to the nature of the dust inhaled.

DIFFERENTIAL DIAGNOSIS OF MINERS' PHTHISIS.

Medical opinion, as well as autopsy evidence, is quite conclusive that true phthisis or pulmonary tuberculosis is not a common disease among coal miners. As stated in the Index of Differential Diagnosis, edited by Herbert French—

> Miners' phthisis is a particular variety of fibrosis due to the inhalation of irritating particles, especially amongst workers at certain occupations. Coal miners seldom get it; although their lungs become packed with carbon—anthracosis—these particles do not seem to inflame the tissues. Knife grinders suffer from it—siderosis—so do workers in certain limestone quarries, rock-drilling, gold mines, and diamond mines—silicosis. The chief point in the diagnosis is the history as to occupation; there is much doubt as to whether these conditions are not really of a chronic tuberculous nature, and tubercle bacilli should be looked for in all these cases. The hæmoptysis is far less frequent and less abundant than it is in ordinary cases of phthisis.

QUESTIONABLE OCCUPATIONAL STATISTICS.

It is therefore quite clear that the correct interpretation of the statistical evidence depends largely upon the completeness and accuracy of death certification, which, it is generally agreed, is frequently far from satisfactory in mining regions. The emphasis placed upon the occupation in the previous reference suggests the practical importance of more extensive special occupational investigations than have heretofore been made. Unfortunately, the scientific value of the available mortality statistics is materially impaired by the superficial, indefinite, or even obviously inaccurate description of the exact employment of the deceased. The previous occupation is rarely referred to, although the occupation at death may have been followed only for a comparatively short period of time. Reference may be made to a suggestive illustration in the monograph on industrial pneumoconiosis, or dust phthisis, by E. B. Collis, which shows a vertical section from the lung of a man who had first been an ironstone miner in England, then a gold miner in the Transvaal, then an ironstone miner in England, and again a gold miner in the Transvaal for five years, but who finally became an insurance agent in England eight years previous to his death from pulmonary tuberculosis.

RELATIVE FREQUENCY OF MINERS' PHTHISIS.

Sir Thomas Oliver was the first to direct attention to the occurrence of a theretofore unknown form of fibroid phthisis in England, contracted during prolonged employment in the gold-mining industry of the Transvaal. Men in whom the condition was observed, upon returning to the lead and tin mines of Cornwall, exhibited symptoms and terminal results quite out of the ordinary for that section of the English mining field.

In the absence of a thoroughgoing past occupational inquiry the initial diagnosis, at least, would often be erroneous. As a result of Sir Thomas Oliver's observations and the public discussion following, the South African Government appointed a commission which in a report published in 1912 stated that out of 3,462 persons examined 31.6 per cent were found to be affected with miners' phthisis, but among machine drillers 47.5 per cent were found to be victims of the disease, while among those who had never done machine drilling the proportion was only 21.0 per cent. It is pointed out in this connection by Frank Shufflebotham, M. A., in one of the Milroy lectures on the "Hygienic aspect of the coal-mining industry in the United Kingdom," that although 31.6 per cent of the men examined were suffering from phthisis at the time of the examination, it was estimated that 90 per cent of the workers would eventually contract the disease. It was also ascertained that among European miners pulmonary tuberculosis existed to the extent of 3.6 per cent among those who were not affected by pneumoconiosis and that of these so affected 10 per cent were tuberculous. The evidence was therefore quite conclusive that pulmonary tuberculosis was a disease contracted subsequently to the so-called fibroid phthisis, which, in other words, is a nontuberculous disease of the lungs.

DISEASE LIABILITY OF ROCK DRILLERS.

The evidence obtained by the miners' phthisis commission of the Transvaal, limited, of course, to miners on the Rand, according to Sir Thomas Oliver, amply demonstrates that—

> Of 4,403 miners working underground in the gold mines of Witwatersrand, 1,200 were medically examined on behalf of the commission; of this number 187, or 15.4 per cent, were certified by the examining doctor to be suffering from miners' phthisis, and a further 88 were suspected. The average age at death of Transvaal gold miners at the time of the war was 35.5 years. Most of the men who died from phthisis were rock drillers, in whom, as a class, the disease prevailed to the extent of 91.98 per cent. The average length of time rock drillers follow their occupation is 6.49 years. It is noteworthy that out of 9.3 males who died from disease of the chest in the Johannesburg hospital 50 per cent were miners. The most dangerous dusty processes in the gold mines are the blasting and boring of the rock, but a considerable quantity of dust is raised also during the shoveling of the débris. A cubic foot of air, taken close to rock-drilling machines boring dry holes, was found to contain 0.185 grain of dust on one occasion and 0.083 grain on another; so that miners working in these atmospheres ran the risk of inhaling 2.38 grains of dust per hour. It is not contended, however, that the whole of this dust reached the lungs of the miners; most of it, caught by the ciliated epithelium, would be arrested in the mucus of the trachea and bronchial tubes, and finally expelled.

PATHOLOGICAL CONSIDERATIONS.

The morbid anatomy of miners' phthisis or silicosis varies, naturally, in important essentials from true tuberculosis, it being stated in part by Sir Thomas Oliver that—

> The hardness and solidity of the lung in pneumoconiosis are due to excessive fibrosis and to the deposition of gritty particles of stone in stone miners' phthisis, of steel and stone in steel grinders' phthisis, and of silica in miners' phthisis. The particles of grit in the lungs have been examined physically and chemically, and have been found to correspond exactly with the particles of dust that float in the atmosphere of the mine or factory where the patient had worked.

With special reference to the results of microscopical examinations of miners' lungs, it is said that—

> Although in anthracosis or coal miners' phthisis the lung is perfectly black, the fibro-connective tissue is not so much increased as in some other forms of pneumoconiosis; a condition which proves that carbon per se is but slightly irritating in its effects. When a coal miner's lung shows pronounced fibrosis it is generally an indication that the individual has worked in a coal seam which contained a quantity of stone; it is the stone dust in the coal, not the coal itself, which in the case of colliers' phthisis is the cause of the fibrosis, for the lungs of men who have worked in soft coal or at charcoal burning and who have inhaled the smoke from lamps, may be laden with carbon particles without much evidence of fibrosis and without the invasion of pulmonary phthisis, as is often seen in the bodies of miners who have been accidentally killed and who had never had any symptoms of lung disease.

The relative degree of the contamination of the air in coal mines by stone dust must naturally be subject to very wide variations, according to the overlying or underlying geological strata, inclusive of coal seams. It is a safe assumption that under given conditions the proportion of stone dust intermixed with coal dust must be sufficiently injurious, particularly during drilling operations when the overlying so-called slate is removed. Much of the drilling, in other words, is in stone rather than in coal, although, of course, in the overwhelming majority of coal mining operations the bore holes are entirely in the coal seam. The information is therefore of quite a conflicting character, largely because of the nonrecognition of the complexity of the problem under consideration. Obviously a general analysis of the mortality of miners is, therefore, as far from conclusive as a corresponding general analysis would be of the stone industry, on account of the wide variations in working conditions and, consequently, the results to health and longevity.[1]

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[1] Textbooks on coal mining fall lamentably short of the required consideration of matters of health, sanitation, and accident prevention. During recent years much useful information in matters of detail has been contributed to technical publications, especially the Coal Age and the Engineering and Mining Journal.

PNEUMOCONIOSIS AND TUBERCULOSIS.

For practical purposes, however, chiefly in connection with the successful solution of problems in workmen's compensation having to do with the inclusion of occupational diseases, the precise relation of pneumoconiosis and tuberculosis is of much importance. As has been said by Sir Thomas Oliver in this connection:

> One party maintains that some of the structural changes met with in the lungs of persons who have worked in dust are tuberculous, and that pneumoconiosis is only the fibroid form of ordinary pulmonary tuberculosis. My own experience does not lead me to accept this conclusion. Pneumoconiosis is in its inception nontuberculous; it may even run its course and end fatally without ever becoming tuberculous. In at least two necropsies which I made on the bodies of Rand miners the lungs were quite free from naked-eye and microscopical evidence of tuberculosis. The absence, during life, of fever, of sweating, and of emaciation, and the presence of a bronzed appearance of the skin, combined with a degree of breathlessness quite out of proportion to the physical signs of the disease in the chest, all indicate that the disease is different from pulmonary tuberculosis. Yet in a considerable proportion of the patients the disease of the lungs becomes tuberculous; whether the percentage of such cases is as low as 47, as some pathologists maintain, or as high as 70, as others assert, the number of cases of miners' phthisis which become tuberculous is not so great after all, considering the length of time the illness lasts and the numerous opportunities for tuberculous infection. The records of any large infirmary show that evidence of pulmonary tuberculosis, latent or active, is forthcoming in nearly 70 per cent of all bodies examined after death. The presence of tuberculosis in from 47 to 70 per cent of cases of pneumoconiosis has given rise to the opinion that all cases are tuberculosis, but this conclusion is not borne out by the clinical data, nor by the results of naked-eye and microscopical examination of the diseased structures. As the disease progresses the patients run the risk of tuberculous infection, the onset of which is shown by sweating, rise of temperature, presence of bacilli in the sputum, rapid emaciation, a change in the symptoms, and by an alteration in the general conditions of the patient for the worse, as indicated by the more rapid course of the disease to a fatal termination.

The observations have been given in full on account of their practical importance and the recognized high authority of the writer, who, as said before, was the first to recognize the occurrence of true miners' phthisis in English miners returning from the Transvaal. Sir Thomas Oliver differentiates completely the two forms of pneumoconiosis: (1) the purely nontuberculous form and (2) that complicated with tuberculosis. He quotes the results of an investigation made by a committee of the Transvaal Medical Society to the effect that "while in some cases a true tubercular phthisis may coexist or may be superadded, the conjunction is only seen in a minority of cases." It would therefore appear that most of the deaths attributed to miners' phthisis are, in fact, caused by nontuberculous lung diseases, complicated to only a very limited extent by a superadded true pulmonary tuberculosis. In the investigation of the royal commission on the ventilation and sanitation of mines in West Australia much the same conclusion was arrived at, to the effect that "Some of the cases investigated were of the purely tubercular type, but in the majority there had apparently been fibrosis of the lung followed by tubercular infection of the damaged lung." And Sir Thomas Oliver quotes Prof. D. J. Hamilton in the statement that "coal miners' phthisis is not a tuberculous process but has more the character of an asceptic slough due to the altered condition of the organ. In the case of the stonemason's lung, on the contrary, a complication with tubercle, at the time of death, or for some time before it, is frequently met with, accompanied by the expectoration of tubercle bacilli." The correct ascertainment of either condition is frequently quite difficult, even on the part of an experienced medical practitioner. Bacilli are rare and so-called giant cells are only occasionally observed. All the evidence, however, may be summed up in the statement that when pulmonary tuberculosis is actually present in the lungs of persons who have died of pneumoconiosis, "the fibrosis is the result of a primary irritation induced by dust, and that the pulmonary tuberculosis is secondary and accidental."

MORTALITY OF MINERS AND QUARRYMEN—UNITED STATES REGISTRATION AREA.

The most recent American vital statistics of miners and quarrymen are limited to the two years 1908 and 1909, no subsequent analysis of the data having been made by the division of vital statistics of the United States Census Bureau. The mortality of miners and quarrymen is combined, so the statistics are, therefore, of rather limited usefulness. In the aggregate there were 10,800 deaths from all causes, of which 948, or 8.8 per cent, were from pulmonary tuberculosis. The details of the mortality, by divisional periods of life, are given in Table 126:

TABLE 126.—PROPORTIONATE MORTALITY OF MINERS AND QUARRYMEN FROM PULMONARY TUBERCULOSIS, UNITED STATES REGISTRATION AREA, 1908 AND 1909, BY AGE GROUPS.

Age at death.	Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent of deaths from all causes.
15 to 24 years	1,491	88	5.9
25 to 34 years	2,184	151	6.9
35 to 44 years	2,122	235	11.1
45 to 54 years	1,869	214	11.4
55 to 64 years	1,430	168	11.7
65 years and over	1,657	88	5.3
Age unknown	47	4	8.3
Total, 15 years and over	10,800	948	8.8

The table should be interpreted with extreme caution, in view of the fact that the miners in the United States registration area are chiefly coal miners, but in a general way the table confirms the conclusion that the recorded mortality from pulmonary tuberculosis among miners and quarrymen, considered as a group, is relatively low at all ages and at specified ages, reaching a maximum of 11.7 per cent at ages 55 to 64. The age distribution of the deaths is in itself significant in that the maximum mortality falls upon ages 35 to 64, in contrast to the usually excessive proportion of deaths from pulmonary tuberculosis in dusty trades at ages 15 to 34. The table indicates that the apparent mortality from pulmonary tuberculosis among miners and quarrymen in all probability includes a considerable number of deaths from miners' phthisis, or nontuberculous lung diseases. This conclusion in part is confirmed by the relatively high mortality from asthma, bronchitis, and other respiratory diseases.

MORTALITY OF MINERS FROM NONTUBERCULOUS RESPIRATORY DISEASES.

Combining all nontuberculous respiratory diseases, the proportion of deaths from this group of causes among United States miners and quarrymen was 12.1 per cent, having been, respectively, 0.7 per cent from asthma, 0.8 per cent from bronchitis, 7.8 per cent from pneumonia, and 2.8 per cent from other respiratory diseases. Combining the mortality from tuberculous and nontuberculous lung diseases, it is shown that 20.9 per cent of the deaths from all causes among miners and quarrymen were attributable to these two groups of causes, in comparison with 29.8 per cent as shown by the Prudential experience, and 32.7 per cent by the statistics for England and Wales.[1]

MORTALITY OF MINERS AND QUARRYMEN—INDUSTRIAL INSURANCE EXPERIENCE.

The Prudential industrial mortality statistics regarding miners are practically limited to coal mining and quarries, but, in so far as the data may prove useful, they are included in the present discussion in the combined form for mines and quarries, including 4.819 deaths from all causes, of which 533, or 11.1 per cent, were from pulmonary tuberculosis. The details of the mortality, by divisional periods of life, are shown in Table 127:

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[1] The Metropolitan Co.'s statistics have reference only to white coal miners aged 15 years and over. Out of 1,557 deaths from all causes, 91, or 5.8 per cent, were from tuberculosis of the lungs; 161, or 10.3 per cent, from pneumonia (all forms); and 49, or 3.1 per cent, from acute and chronic bronchitis. Information for other nontuberculous respiratory diseases is not available in detail.—(See Bulletin No. 207, United States Bureau of Labor Statistics on "Causes of Death by Occupation," Washington, March, 1917.)

TABLE 127.—PROPORTIONATE MORTALITY OF MINERS AND QUARRYMEN, FROM PULMONARY TUBERCULOSIS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914,[1] BY AGE GROUPS.

Age at death.	Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent of deaths from all causes.
15 to 24 years	561	48	8.6
25 to 34 years	563	92	16.3
35 to 44 years	650	106	16.3
45 to 54 years	1,043	142	13.6
55 to 64 years	1,163	105	9.0
65 years and over	839	40	4.8
Total, 15 years and over	4,819	533	11.1

[1] Miners and workers at coal and lead and zinc mines cover the period 1907 to 1914 only.

The comparatively low proportionate mortality from pulmonary tuberculosis in the Prudential experience is confirmed in a general way by the corresponding statistics for the United States registration area, but throughout the proportions are higher, which in part may be explained by adverse selection, and in part by the practical limitation of the table to actual miners rather than men employed in the mining industries. The United States registration data have reference rather to all employments in connection with mines and quarries, while the Prudential statistics are more strictly limited to miners and quarrymen within the technical sense of the term.

EXCESSIVE FREQUENCY OF NONTUBERCULOUS RESPIRATORY DISEASES.

In contrast to a relatively low proportionate mortality from tuberculous disease, the proportionate mortality from nontuberculous respiratory diseases was relatively high, or 18.7 per cent of the mortality from all causes, which compares with only 12.1 per cent for the mortality of miners and quarrymen in the United States registration area. The same conclusions apply here, with more strict occupational limitations in the Prudential statistics, which exclude a considerable proportion of persons employed in the mining industries who work under practically noninjurious conditions as regards dust exposure and predisposition to tuberculous or nontuberculous lung diseases. In view of the fact that each important branch of the mineral industry is separately considered in the following discussion it would serve no useful purpose to here repeat the data, which it may be said, however, in a general way are confirmed by the official English statistics and the corresponding official statistics for the United States. The differences in the results are attributable to widely varying conditions of employment in the mining industries, the variable degree of disease exposure as affected by territorial considerations, and adverse occupational selection in industrial insurance experience, etc.

GOLD AND SILVER MINING.

The term "gold and silver mining" comprehends several important and widely different methods of ore extraction. The precious metals, as such, are of no hygienic importance. Gold and silver as extracted by the ordinary processes of deep mining constitute but a minute fraction of the ores, which, however, frequently contain a relatively large proportion of lead. The rock itself is generally a silicious quartz which, during the process of rock drilling, seriously contaminates the atmosphere underground, often with disastrous results to the miners' lungs. The term "gold and silver mining" is, therefore, of importance only in so far that mining for the purpose of extracting the precious metals, is, as a general rule, inseparable from exposure to more or less health-injurious silicious dust. Many gold and silver mines, as measured by the metallic content of the ore, are more accurately described as lead mines. Most of the gold is obtained by deep-mining methods, but a fair proportion is recovered by means of placer mining, hydraulic mining, dredging, etc. In these latter processes the dust exposure is of decidedly less importance, since most of the operations are carried on in the open. No extended official inquiry has ever been made in this country into the health and mortality of gold and silver miners, although the industry, for many years, has been one of relatively large economic importance. According to the report of the U. S. Bureau of Mines for 1915, the number of men employed in connection with gold and miscellaneous metal mines, other than iron, copper, lead, and zinc, was 45,312. The industry is chiefly concentrated at the present time in Alaska, California, and Colorado. In all of the States the underground conditions vary considerably on account of important differences in the chemical and mechanical properties of the rock dust inhaled during drilling and other underground operations. It is only within recent years that the dust hazard has been clearly recognized, and among other suggestive indications of a tendency toward an improvement in underground conditions, reference may be made to the following tentative rules and regulations of the California Industrial Commission:

SECTION 41.—ELIMINATION OF ROCK DUST.

(*a*) No operator or person in charge of any underground mine shall cause to be drilled or bored by machinery a hole or holes in any working place in-ground that causes dust from drilling, unless said machinery is equipped with a water jet or spray, or other means equally efficient to prevent the escape of dust; *Provided*, That when water jets or sprays are used, water free from pollution with organic or other noxious matter, shall be furnished.

(*b*) No person or persons shall drill or bore a hole in said working places without using said appliance for the prevention of dust.

(*c*) Every mine operator shall equip all chutes from which dusty ore or rock is taken with a sprinkler or other device with which to effectively dampen said ore or rock, to prevent the escape of dust into the air during removal; *Provided*, That whenever in the opinion of the chief inspector the installation of said device in any property is impracticable, he shall have the power to exempt such property.

(*d*) Whenever a sprinkling device is installed at any chute for the purpose of preventing the escape of dust, it shall be so placed that it can be operated by the workmen loading cars from such chute.

(*e*) Every ore house where dusty rock or ore is sorted shall be supplied at all times with suitable clean water, which shall be used for the purpose of sprinkling said ore or rock to allay the dust.

Of interest also in this connection is a resolution adopted by the board of directors of the National Association for the Study and Prevention of Tuberculosis in 1911, reading as follows:

Whereas the royal commission, appointed by the governor general of Australia to inquire into the subject of miners' lung diseases, has ascertained a truly alarming state of affairs resulting from the extensive use of rock drills underground, not provided with spraying apparatus to diminish the production of health-injurious dust; and

Whereas a large proportion of our mining population is exposed to conditions quite similar to those reported upon adversely in the Australian Commonwealth; and

Whereas the actual extent of the occurrence of lung diseases among metal miners in the United States is at present unknown.

Resolved, by the board of directors of the National Association for the Study and Prevention of Tuberculosis, That we recommend to the President and the Congress of the United States that a thorough investigation into the whole subject of sanitary conditions surrounding metal mining underground, with special reference to diseases of the lungs, be made by the United States Bureau of Mines, the Public Health and Marine-Hospital Service, and the appropriate State authorities.

The effect of this resolution has been that both the Public Health Bureau of the Federal Government and the Bureau of Mines have commenced tentative investigations into the sanitary condition of mines and the health of miners, and with regard to zinc and lead mines of southwestern Missouri a preliminary report has been made, as referred to elsewhere in some detail.

In the absence of trustworthy vital statistics and the results of a sufficient number of physical examinations of underground employees in gold and silver mines, no definite conclusions can be advanced at the present time. The most useful data are the results of exhaustive investigations in South Africa, Western Australia, and New South Wales, elsewhere referred to. The problem, however, will unquestionably require more qualified consideration in the future, in view of the probability that miners' phthisis, or miners' lung diseases, whether tuberculous or nontuberculous will, in course of time, be brought within the scope of the workmen's compensation law. On the Witwatersrand, in South Africa, where miners' phthisis is a veritable scourge among both the white and the native employees, compensation is paid under restricted conditions, and according to a discussion in the Engineering and Mining Journal for January 2, 1915, up to the end of January, 1914, as much as £1,163,000 ($5,659,740) had been granted in awards. Serious difficulties, chiefly on the ground of malingering, have been experienced in the administration of the act, partly attributable to the medical difficulty of the necessary precise diagnosis of silicosis. In consequence of the act, however, the conditions underground inimical to health and life are gradually being brought under sanitary and medical control. It is said in the article referred to, which is a discussion on phthisis conditions on the Rand, by A. Cooper Key, editor of the South African Mining Review, that "Medical members of the committee had not formed any definite opinion as to the relation between the amount of dust and the occurrence of the disease. They could not say that with such an amount as even 5 milligrams per cubic meter a man could not certainly contract miners' phthisis." Evidence gradually accumulating proved conclusively that the dust found in the silicotic lung after death was of extraordinary fineness, so that, in other words, only the very fine dust in the mine was most likely to be inhaled and to reach the lungs. Methods of dust control along the line of dust reduction seem not to guarantee a relative freedom from liability to miners' phthisis, for it is said that "with all the precautions taken, the 5 milligrams now remaining may be doing as much injury as the 50 or more before." The dust found in the lungs on postmortem was so fine that "50 particles in a row would be about as thick as a hair." These observations suggest the very important conclusion that it would not seem advisable that "mines, proved to be practically free of dust, should be removed from the list of contributors (to the compensation fund), as it was doubtful if they were not still causing phthisis." Time and subsequent experience alone can prove whether it would be safe to relieve a carefully managed mine, on the basis of dust standards, from the duty of making contributions to the compensation fund.[1]

LEAD AND ZINC MINING.

The available information regarding lead and zinc mining in the United States is practically limited to the mining districts of the Mississippi Valley, where, according to the returns of the Bureau of Mines for 1914, the number of men employed in lead and zinc mines was officially reported as 10,935, of whom 7,609, or 69.6 per cent, worked underground. Of the zinc produced in the United States, 38.26 per cent during 1913 was obtained in Missouri, 19.23 per cent in Colorado, and 10.56 per cent in Montana. In Missouri zinc and lead mining is practically an identical industry, but in some of the more western States the recovery of lead is chiefly in connection with the mining for precious metals. Of the United States lead production during 1913, out of a total of 436,000 tons, 152,430 tons, or 35 per cent, came from Missouri; 137,802 tons, or 31.6 per cent, from Idaho; and 71,069 tons, or 16.3 per cent, from Utah. Aside from Colorado, where the production during 1913 was 42,840 tons, the production in the remainder of the United States is comparatively unimportant. It is explained in the annual report of the United States Geological Survey on the mineral resources for 1913 that the product of refined lead can with difficulty be apportioned according to the sources of ore, owing to the fact that lead refiners treat smelted products whose origin may, as in custom refining, be unknown to them, the identity of the ore and thus its original source being preserved only so far as the smelter. The mines of the Mississippi Valley were originally worked exclusively for lead, but since 1860 the production of zinc ore has predominated, which makes a separate consideration of each metal in this important mining area practically impossible. In Idaho, however, for illustration, most of the ores mined are strictly lead ores even though the object of the mining is the recovery of the precious-metal content.

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[1] The comparative statistics of mortality from accidents and violence and disease, according to race, as reported by the Transvaal Chamber of Mines in its annual report for 1916, are of much interest and value

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in this connection, but they must be used with exceptional care on account of the probable effect of the war on the death rate and selection of the men employed during the last two or three years.

Mortality of mine employees in the Transvaal.

[Rate per 1,000 employed—white and colored.]

Year.	White.			Colored.		
	Accident and violence.	Disease.	Total.	Accident and violence.	Disease.	Total.
1906	4.7	12.3	17.0	4.9	29.1	34.0
1907	5.6	12.2	17.8	4.4	27.3	31.7
1908	4.7	13.9	18.6	4.1	29.1	33.2
1909	4.9	12.3	17.2	5.2	27.6	32.8
1910	3.8	11.4	15.2	4.5	29.7	34.2
1911	4.3	12.9	17.2	4.1	28.9	33.0
1912	3.0	14.9	17.9	4.1	24.2	28.3
1913	3.6	13.5	17.1	3.9	22.9	26.8
1914	3.9	11.8	15.7	3.4	15.1	18.5
1915	3.0	15.0	18.9	3.2	16.5	19.7
1916	3.6	15.6	19.2	3.4	13.7	17.1

Most of the official inquiries into the health conditions of this group of mine employees have been limited to lead mining, chiefly, however, with reference to the United Kingdom. As subsequently to be stated, the only important exception to this conclusion applies to the lead and zinc mines of southwestern Missouri, where a fairly thorough investigation has during recent years been made by the United States Bureau of Mines in cooperation with the United States Public Health Service. All official investigations in this and other countries are apparently in agreement that the health of lead miners is distinctly below the average for the mining industry as a whole. This unfavorable condition is not merely with reference to the special liability to lead poisoning, but much more so with reference to general underground conditions. Greenhow, in one of the earlier investigations into the several mining districts of England and Wales, brought out clearly the injurious nature of the lead miner's employment, and proved that the predominating cause of death was then, as now, to be attributed to pulmonary disease, chiefly, as far as determined, pulmonary tuberculosis. Parry, in his treatise on "The risks and dangers of various occupations," especially in connection with lead, copper, and tin miners, observed that of the various forms of metalliferous mining, these are all attended by a very high rate of mortality from chest diseases caused by the dust inspired. He concludes—

> Perhaps the chief reasons of the high mortality of those engaged in these mines, when compared with coal miners, are, firstly, that the mines from their nature are more difficult to drain and ventilate than are coal mines; secondly, from the fact that the dusts are metallic and poisonous, and composed of sharp, angular, irritating particles; and, thirdly, that explosives are used in these mines, which generate poisonous gases and cause the formation of large numbers of minute stony atoms. They, however, do possess one advantage over coal mines—they seldom produce explosive and poisonous gases, and can therefore be worked safely without lamps. In lead mines the ore chiefly mined is galena, a sulphide of lead, and the dust of this occasionally, though not commonly, gives rise to lead poisoning. Dust is also produced during blasting operations, and whilst the various strata of limestone, sandstone, and shale, especially the latter, are being cut through. The importance of the perfect ventilation of these mines from the health point of view can hardly be overestimated; the comparison of the deaths from lung trouble in the workers in two mines, one of which is properly, the other improperly ventilated, amply proves the advantages accruing from the removal by ventilation of the dusty atmosphere. In tin and copper mines the dust is produced, again, during the blasting operations and whilst cutting through the various rocks. Nothing need be added to what has already been said above on lead mining.

The risk of lead poisoning is usually of importance only during the initial mining operations. With increasing depth the risk, on account of alterations in the nature of the ore, rapidly diminishes until cases become extremely rare. This, at least, has been the experience in the Coeur d'Alene District of Idaho, where years ago lead poisoning was relatively common among lead miners but where now it is seldom met with. Foreign observations seem to lead to much the same conclusion, for, as observed by Sir Thomas Oliver in his "Diseases of Occupation":

> Lead miners do not in this country suffer from lead poisoning, but as the mines are badly ventilated, are often wet, and entrance into and exit from them can only be effected by means of ladders the men suffer in their general health and from rheumatism. In the dales of Durham house accommodation near the lead mines is difficult to obtain. Consequently many of the men have long distances to walk from and to home. At the end of a day's work, when heated and fatigued, they are thus exposed in winter to the cold winds that sweep along the valleys. Bronchitis and lung diseases claim a large number of victims. The deadliest enemy is tuberculosis. Formerly, when lead mining was more of an industrial success than it is to-day, the men were housed in barracks close to the mines and returned to their homes at the week ends. These barracks were overcrowded and badly ventilated and were hotbeds of tuberculosis. In the sleeping rooms not only was the air space insufficient and the beds too close to each other, but the windows were never opened, and miners who were the subjects of bronchial catarrh and tuberculous lung disease simply expectorated on the floor of the dormitories. Overcrowding, the breathing of foul air and of the dust-laden atmosphere of the sleeping rooms favored the spread of tuberculosis. As a consequence of these and of exposure to severe weather, also inattention to "colds on the chest," lead miners, although living in healthy districts, have succumbed to phthisis in much larger number than other persons living in the same district.

Obviously the social and economic condition of the industry has an important bearing upon the health problem aside from the health-injurious conditions underground, which more or less predispose the miner to pulmonary tuberculosis and nontuberculous respiratory diseases. According to the English occupational mortality statistics, out of 373 deaths of occupied and retired lead miners from all causes only 1 death was attributed to lead poisoning. In marked contrast the same official returns show that out of 162 deaths from all causes among persons employed in lead manufacture, including the making of leaden goods, 9 deaths, or 5.6 per cent, were from lead poisoning. The evidence would therefore seem to be quite conclusive that the special risk of lead poisoning in lead mining is at present quite negligible, although, as previously pointed out, important exceptions occur in the case of new lead-mining districts. It may be said in this connection that, according to Sir Thomas Oliver's "Diseases of Occupation"—

> The lead miner does not suffer from plumbism, owing to the fact that the ore contains lead in almost a pure metallic state; but at the

Broken Hill mines in Australia the ore contains lead in the form of carbonate, and several of the miners there have died from saturnine encephalopathy, or the cerebral type of lead poisoning attended by convulsions.

These observations, of course, have no reference to the liability to plumbism in lead smelting and refining, which is usually carried on as a separate industry. Lead poisoning, however, is of practical importance in a consideration of the liability to pulmonary tuberculosis, in that the opinion is held by qualified authorities that the former disease distinctly predisposes to the latter, or that, in other words, those liable to lead poisoning suffer an increased liability to pulmonary tuberculosis.[1]

The only conclusive data regarding the mortality of zinc and lead miners in the United States are limited to the industrial insurance statistics for the mining districts of southwestern Missouri. In Table 128, which, though limited to 96 deaths from all causes, is nevertheless extremely suggestive of an excessive proportion of deaths from pulmonary tuberculosis, equivalent to 49 per cent, against 13.9 per cent for males in the United States registration area.

TABLE 128.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG LEAD AND ZINC MINERS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1907 TO 1914, COMPARED WITH THAT OF ALL MALES IN THE UNITED STATES REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of lead and zinc miners, 1907 to 1914, from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Lead and zinc miners.	Males in registration area, 1900 to 1913.
15 to 24 years	15	5	33.3	27.0
25 to 34 years	29	17	58.6	30.5
35 to 44 years	26	16	61.5	23.4
45 to 54 years	15	8	53.3	14.7
55 to 64 years	8	1	12.5	7.9
65 years and over	3	....	....	2.6
Total, 15 years and over	96	47	49.0	13.9

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[1] The white lead industry might appropriately have received some consideration in connection with this discussion, but as far as known the employees in this industry are not exceptionally subject to pulmonary tuberculosis or nontuberculous respiratory diseases. During recent years far-reaching sanitary and other improvements have been introduced into the American white lead industry, with the result that the frequency of lead poisoning has been much reduced. In some plants the disease has practically been eliminated. Some of the larger establishments have been entirely reconstructed and, as far as practicable, in conformity to modern sanitary standards. There is, however, unquestionably a considerable amount of dust exposure, and a strictly scientific inquiry would be desirable. Such an investigation with special reference to the health of employees is rather difficult on account of the fact that the labor turnover is considerable since the labor force consists largely of foreigners and negroes. Health-injurious conditions, therefore, common to foreign white-lead plants where employment is more permanent are probably relatively rare in this country for the reasons stated.

Out of 96 deaths from all causes the extraordinary number of 47, or 49 per cent, are caused by deaths from pulmonary tuberculosis, in contrast to the expected proportion of 13.9 per cent. At ages 35 to 44, however, the proportionate mortality attains to 61.5 per cent, in contrast to the expected proportion of 23.4 per cent.

The investigation by Messrs. Lanza and Higgins was in consequence of a continued agitation for an inquiry into a truly alarming state of affairs. Various efforts made to abate the causes of the trouble resulted in the formation of the Jasper County (Mo.) Antituberculosis Society, which subsequently, on the basis of statistical information and the reports of visiting nurses, brought much important information to public attention. The general opinion in Jasper County, it is stated in the report referred to, seemed to be that "lung diseases became more prevalent after the beginning of active mining in the so-called sheet ground, in the early eighties, and that the flint dust from drilling and other mine operations is largely responsible for this condition." Both the records of the State board of health and the Jasper County Antituberculosis Society had established an unusual prevalence of tuberculosis in that county and southwestern Missouri. According to the report, after allowing for differences of opinion, inaccuracies, errors, and exaggerations—

> An impartial investigator can not but conclude that when working conditions in any locality are such as to expose the workers to a hard, flinty, insoluble rock dust, and when among those workers there is a high death rate from pulmonary tuberculosis, that there is a definite connection between the dust and the disease, and that the dust is largely responsible for the disease—not entirely responsible for all pulmonary disease, but a prime factor in its causation.

In support of this conclusion attention is directed to the high proportionate mortality from pulmonary tuberculosis in Jasper County, including Webb City and Joplin, where 14.8 per cent of the deaths from all causes were from pulmonary tuberculosis, and in St. Francois County, another lead and zinc mining center, where the proportion was 11.8 per cent. These proportions are for 1911, but even higher figures were shown for 1913, as brought out by Table 128, which includes some comparative data for other sections of Missouri.[1]

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[1] The health-injurious conditions in the Joplin district are, however, in all probability, not limited to underground mining. There has apparently been no qualified and extensive inquiry into the health aspects of employment in ore dressing. For a strictly scientific account of ore dressing methods in the Joplin district see a series of articles by James L. Bruce, general manager, Continental Zinc Co., Engineering and Mining Journal, February–March, 1912. Mr. Bruce directs attention to the fact that the ore mills are poorly housed; that the winter season is short, with only a few extremely cold snaps, and that consequently little consideration is given to the adequate protection of the machinery, which, of course, applies also to the inadequacy of the protection for the men. How far defective methods of mill construction affect the exposure of the employees to health-injurious conditions in the four fundamental operations of crushing, coarse concentration, fine concentration, and the disposition of waste has not as yet been determined.

TABLE 129.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS IN SPECIFIED COUNTIES OF MISSOURI DURING 1913.

County.	Population (1910).	Total number of deaths.	Deaths from pulmonary tuberculosis.		
			Number.	Per 100,000 population.	Per cent of total deaths.
Jasper (including Webb City and Joplin)	89,673	1,324	206	229.7	15.5
St. Francois	35,783	518	68	190.0	13.1
Greene (including Springfield)	63,831	847	63	99.2	7.4
Jackson (including Kansas City)	283,522	4,487	396	139.6	8 8
St. Louis (city)	687,029	10,972	987	143.6	9.1
Buchanan (including St. Joseph)	92,920	1,364	108	116.2	7.9

Table 129, derived from the report of the Bureau of Mines, is amplified by more extended data for the lead and zinc producing counties of Missouri, for the five years of 1911–1915. To make the data as complete as possible the eastern section is also included.

TABLE 130.—MORTALITY FROM PULMONARY TUBERCULOSIS AND NONTUBERCULOUS RESPIRATORY DISEASES IN THE LEAD AND ZINC PRODUCING COUNTIES OF MISSOURI, 1911 TO 1915.

Eastern section.

County.	Production in tons.	Pulmonary tuberculosis.		Respiratory diseases.	
		Deaths.	Rate per 100,000 population.	Deaths.	Rate per 100,000 population.
Franklin	116	136	91.7	171	115.3
Jefferson	3,363	177	123.9	167	116.9
Madison	86,933	97	165.9	65	111.2
St. Francois	1,246,374	290	146.7	312	157.8
Washington	17,284	102	154.7	96	145.6
Total	1,354,070	802	130.8	811	132.2
Western section.					
Green	6,870	402	119.2	541	160.4
Rural		115	78.0	173	117.3
Springfield		287	151.3	368	193.9
Jaspar	1,188,091	984	215.1	682	149.1
Rural		390	170.3	312	136.2
Joplin		387	237.0	269	164.7
Webb City		207	317.6	101	154.9
Lawrence	7,825	161	126.4	196	153.9
Newton	47,605	169	124.4	183	134.7
Ozark	1,694	61	102.7	30	50.5
Total	1,252,085	1,777	159.0	1,632	146.1
Total mining area and remainder of State.					
Mining area	2,606,155	2,579	149.0	2,443	141.2
Balance of State	185	19,470	129.4	21,924	145.7

According to this table, the general death rate from pulmonary tuberculosis in the mining sections of Missouri, as regards lead and zinc ores, was 149.0 per 100,000 of population during the five-year period under review. For the eastern counties considered as a group the rate was 130.8 against 159.0 for the western counties. The mortality from nontuberculous respiratory diseases was also definitely higher in the western counties, or 146.1 against 132.2 for the eastern counties; but in the remainder of the State the rate for this group of diseases was somewhat higher, or 145.7.

Considered by individual counties, however, it is shown that in St. Francois County, which is the chief center of production, the mortality from pulmonary tuberculosis was above the average for the eastern counties. The rate for pulmonary tuberculosis was 146.7 and for nontuberculous respiratory diseases 157.8. There can be no question of doubt, therefore, that the mining industries of this county are primarily responsible for this excess in the mortality from both tuberculosis and the nontuberculous respiratory diseases in St. Francois County.

In the western mining area the pulmonary tuberculosis death rate was highest in Webb City, or 317.6 per 100,000 of population. It was next highest in Joplin City, or 237.0 In the rural portion of Jaspar County the rate was only 170.3. How far the excessive rates for Joplin and Webb City are the result of local hospital admissions and the nonassignment of deaths to the original place of residence can not be stated. For Jaspar County as a whole the rate was 215.1, a rate not reached by any other county in the mining area. Of special importance is the relatively low rate of 124.4 for Newton County, although this area is a considerable center of production.

The nontuberculous respiratory diseases prevail also to an excessive degree in Joplin and Webb City, or respectively, 164.7 and 154.9 per 100,000 of population, against an average of 146.1 for the western mining area as a whole. The highest rate prevailed in Springfield, Green County, although this particular section is not a center of production. The tuberculosis death rate of Springfield, however, was slightly below the average for the western area, or 151.3, while for Green County as a whole the rate was only 119.2.

Assuming that the rate for the nonmining areas of the State may be considered as a fairly trustworthy index of normal conditions, it is suggestive that out of the 10 counties in the zinc and lead mining areas only 4 should show rates distinctly and even decidedly above this average. This would suggest that the pulmonary tuberculosis problem in its relation to lead and zinc mining is very much localized and that therefore thoroughly specialized investigations should prove productive of good results. The same conclusion applies to the mortality from nontuberculous respiratory diseases, for which the rate was above the average for the nonmining areas in only 4 out of the 10 counties. There is no well-defined correlation, however, between a definite degree of excessive incidence of pulmonary tuberculosis and a correspondingly high mortality from nontuberculous respiratory diseases in the zinc and lead producing counties of Missouri.

The preceding data suggest the practical value of further and more strictly scientific investigations into the problem of miners' phthisis in the zinc and lead producing counties, not only of southwestern Missouri, but also in the eastern mining area. The investigation should include a careful inquiry into the mechanical and chemical properties of the zinc and lead areas of the different mining areas, which should not be difficult in view of the excellent reports which have been made on the geology of the lead and zinc producing counties by the United States Geological Survey. The investigation by the Bureau of Mines while limited in plan and scope is a useful indication of research work into a much neglected aspect of the mining industry in this country.

Preliminary to the investigation in southwestern Missouri a physical examination was made of miners. Only 93 were examined, but of this number 64 showed plain and definite evidence of pulmonary disease. Of the 64 sick employees 22 had stopped work on account of their health, the remaining 42 being still at work underground. Of the 64, 39 had the classical symptoms of pulmonary tuberculosis, including night sweats, cough, hemorrhage, loss of weight, and fever. With reference to the results of the examination it is said that "the figures can not be considered as showing the percentage of tuberculosis among miners generally in the county, as those who applied for examinations probably had symptoms which made them suspect they had the disease." There is no doubt some force in this conclusion, and a much larger number of physical examinations would be required for a final determination as regards the true incidence of the disease among the lead and zinc miners of southwestern Missouri. Such an investigation should be made with a due regard to age, length of mine employment, work actually performed, and some additional observations regarding possible previous employment in other mining regions. A. J. Lanza, M. D., in a subsequent report on miners' consumption in southwestern Missouri, in the journal of the Missouri State Medical Association, St. Louis, 1916, is briefly reported as having presented the results of a series of physical examinations of 720 miners, of whom 433, or 60.1 per cent, exhibited definite signs of lung injury, and of this number 103 had also ascertainable tubercle bacilli in their sputum. The most prominent symptom observed was dyspnea on exertion, or, in other words, shortness of breath. It is said in continuation of the statement referred to, that—

> A summary of the symptoms and the physical signs gives us three distinguishing features of miners' consumption. First, a gradually increasing dyspnea, with pain in the chest and diminished expansion; second, an absence of physical signs, or an absence of apparently adequate physical signs; third, the appearance of good health. While the sputum may serve to clear up the diagnosis occasionally, it is on a knowledge of the patient's occupation that the diagnosis largely depends. The disproportion between symptoms and signs distinguishes between miners' consumption and tuberculosis; the degree of dyspnea observed in the former would in tuberculosis be compatible only with far-advanced cases with ample physical signs. Even where a tuberculous infection is grafted on a silicosis, the resulting clinical picture may not, and often does not, resemble ordinary tuberculosis.

The conclusion may, therefore, be advanced that underground employment in the zinc and lead mines of southwestern Missouri unquestionably predisposes in a most serious manner to pulmonary tuberculosis; but the question may be raised whether in the investigations referred to the true form of miners' phthisis or nontuberculous fibroid lung disease was precisely differentiated from the true form of pulmonary tuberculosis, since even in the cases referred to, out of 433 miners showing definite signs of lung injury, only 103, or 23.8 per cent, were found to present definite bacillary evidence of the disease. The reports thus far published are, however, inconclusive on this point.

Special consideration was given to temperature and humidity and to causes of dust production, chiefly, apparently attributed to the so-called blowing of dry holes, the dust caused by "squibbing" and bowlder popping, by drilling, shoveling, and other operations. Most of the dust was naturally found at the working faces, and only a relatively small number of men were found to be exposed to the most dusty atmospheric conditions. The report is a promising indication of future research work in a most important direction. Fairly extensive scientific tests were made of the nature of the dust inhaled, and the quantitative conditions of exposure, the results of the entire investigation being summed up in the following conclusions:

> 1. The death rate from pulmonary diseases is unusually high among the miners of the Joplin district.
>
> 2. Poor housing, exposure, alcoholism, the use of common drinking receptacles, and overwork all tend to spread infection and lessen the power of the miner to resist disease, but the prime factor in causing pulmonary trouble is the rock dust in the mines.
>
> 3. Rock dust in the sheet-ground mines, although not made in great quantity as compared to mines with more restricted working places, is harmful to the miner for two reasons: (*a*) Because he is exposed to it practically during his entire shift, and (*b*) because the

dust is made up chiefly of particles of insoluble flinty chert with splintered and knifelike edges.

4. This rock dust is produced by the blowing of dry holes, squibbing, bowlder popping, drilling without water, shoveling, tramming, roof and pillar trimming, and the dumping of the bucket at the surface.

5. By observing certain precautions rock dust in the mines can be almost entirely abated.

6. There are certain abuses connected with the piece system of work that demand attention and correction as far as practicable.

On the basis of the foregoing conclusions the following recommendations were presented, and it may be said that some of these have subsequently been carried into effect, either through the cooperation of mine owners and employees or through legislative enactment:

1. The following means should be employed for the abatement of rock dust in the mines:

(*a*) Provide a water supply for every working face by the laying of a separate water line.

(*b*) Where drills are operated without water, attach to the hose leading to the face a 5 or 6 foot length of pipe with a nozzle from one-eighth to one-fourth inch in diameter. Make and enforce such regulations as will insure the use of this water spray for the purpose of wetting drill holes, the face, and the broken rock about the face. For the purpose of washing drill cuttings from drill holes this hose may be attached to the long pipes now in use for blowing out drill holes.

(*c*) Where there is in use some type of drilling machine that provides for water passing through the core of the drill steel into the drill holes, make and enforce regulations that will insure the spraying of the face and broken rock for short periods at such times as the drill may not be in operation. For this purpose the water hose must be uncoupled from the drilling machine unless separate water connection is provided.

(*d*) Make and strictly enforce rules against squibbing and bowlder popping while the shift is underground and against the blowing of dry holes at all times.

(*e*) Improve ventilation by the opening of new shafts whenever practicable.

2. Do away with common drinking cups and kegs and water pipes which allow the miner to bring his lips in contact with the orifice. Substitute the well-known sanitary drinking fountain when practicable or have miners bring their own water supply in individual containers.

3. Do not employ as shovelers men under twenty years of age.

4. Through cooperation among the operators provide a maximum daily tonnage for shovelers, so that they can not injure their health through overwork.

5. Provide a warm, dry, and clean place in which the miners may change their clothes.

6. Through intensive educational campaigns in the public schools and among the miners themselves disseminate information as to the

harmful effects of insanitary practices and conditions, such as crowded living quarters, overwork, exposure, dissipation, the breathing of air polluted by powder fumes and rock dust, and the use of common drinking devices.

Thus far there has been no correspondingly extensive inquiry into the health conditions of other mining districts in this country; but in course of time, no doubt, such investigations will be made through the cooperation of the Bureau of Mines, the United States Public Health Service, and local mining and health authorities.

Aside from the foregoing observations of methods and means of dust prevention, it seems appropriate to include a brief but exceptionally instructive article on a new method of dust arresting during drilling and boring, from the Coal Age for September 26, 1914:

> Much attention is being paid at present to the avoidance of free or floating dust during drilling or boring in stone, coal, or other materials. One method of attacking this problem is by directing a spray of water onto the part where drilling is in progress, but this is not always possible, unless a supply of water is easily available.
>
> An alternative arrangement which has been introduced by Holman Bros., of Camborne, England, under the patents of M. T. Taylor, consists of providing the drilling or boring machine with a means of arresting and collecting the dust so that it can not permeate the air.
>
> The boring tool is provided with a cup or receptacle slipped over the shank and having a soft-edged mouth, which accommodates itself to the rock surface when pressed against it. The soft edging at the mouth of the receptacle is secured by a sponge collar or gasket. At the lower part of the receiver a nozzle is arranged, from which the dust is led away through a hose into bags or a water trough. A gland closed at the lower end by a rubber washer fits around the drill. The machine when it commences to bore compresses a spiral spring, which butts against the cup receiver and forces it against the rock surface and the dust on coming out of the hole, being unable to make its escape because of the soft edging, passes away through the dust-collecting duct into the receptacle provided.
>
> The whole arrangement is extremely simple, and easily applied. Its simplicity of application is a strong point in its favor, inasmuch as the average miner is prone to give but little attention to his physical condition if such attention involves any extra trouble in the operation of his equipment. It is to be hoped that with the introduction of dust-allaying devices, miners' phthisis, of which so much has been heard in recent years, will be done away with, or at least effectively curbed.

It may also be said in this connection that a comparatively simple and inexpensive method of dust control has been devised by Mr. Thomas E. Mitchell, and an illustration of the method as employed in the Leonard mine, of Butte, Mont., is given in the monthly bulletin of the American Museum of Safety for March, 1914. The dust, according to this method, is accumulated in a canvas bag, and, with reasonable efficiency, is prevented from contaminating the atmosphere in otherwise exceptionally dusty stopes, to the material advantage of the workmen. All such methods, of course, must as yet be considered tentative, and the practical solution of the question of dust control in underground mines remains a problem for the future.[1]

COPPER MINING.

In copper mining the health-injurious conditions, with special reference to pulmonary tuberculosis and nontuberculous respiratory diseases, are much the same as in gold and silver mining. The copper content of the ore represents but a small fraction of the rock extracted, and, as far as known, the metal itself is not, in the condition as mined, injurious to health. The number of men employed in copper mining in 1914, according to the report of the Bureau of Mines, was 44,686, the chief centers of production being in Arizona, Michigan, and Montana. In Utah and Nevada most of the copper mined is obtained by other than underground mining methods, chiefly in the form of stripping, which, of course, involves a much lesser degree of dust exposure. For this reason the comparative mortality of copper miners from pulmonary tuberculosis and nontuberculous lung diseases, varies quite considerably in the two States of Utah and Montana. In the latter State most of the copper ore is derived from very deep mines, where the sanitary problem is frequently seriously complicated by exceptional conditions of temperature and humidity. No thorough investigation has thus far been made into the health and mortality of copper miners in this country, but it is practically certain that at least a preliminary inquiry will be made in this direction by the United States Bureau of Mines in the near future.[2] The only available statistics are with reference to the mortality of miners in the Butte district of Montana, obtained by means of a special analysis of 1,614 death certificates recorded in the city of Butte during the period 1907 to 1914. The results of this analysis, first exhibited by The Prudential Insurance Co. of America on the occasion of the Fifteenth International Congress on Hygiene and Demography, but brought down to date for the present purpose, are shown in Table 131.

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[1] Of practical value in this connection is a recent publication of the Bureau of Mines on the dust problem in the iron and steel industry, with illustrations of methods of dust analysis, etc. See Technical Paper 153, entitled "Occurrence and Mitigation of Injurious Dusts in Steel Works," by J. A. Watkins; Washington, 1917.

[2] In this connection the "Yearbook of the Bureau of Mines" for 1916 gives information as follows:

> In May, 1916, the Bureau of Mines, in cooperation with the Public Health Service, undertook, in the mines of Butte, Mont., an investigation into health hazards, particularly silicosis. It was thought that the investigation would closely parallel that carried into effect in the Joplin region, but as the investigation has developed its scope has necessarily widened, and it is probable that before definite conclusions can be reached careful study must be made not only of dust conditions and of methods of allaying the dust, but also of problems of ventilation, heat, humidity, etc., which appear to have a direct bearing on health conditions in general as well as on silicosis. There are approximately 40 large mines in Butte, many of which have men working to depths as great as 3,300 feet, and there are approximately 15,000 miners in the district. Progress reports are being made from time to time, and a final report will be made on completion of the investigation.

TABLE 131.—MORTALITY FROM RESPIRATORY DISEASES AND FROM ALL CAUSES AMONG COPPER MINERS OF MONTANA, 1907 TO 1914, BY AGE GROUPS.

[Data are based on an original office investigation, including a transcript of all death certificates indicating deaths of miners in Butte, Mont., through the cooperation of the local board of health.]

Age at death.	Deaths from—									
	Tuberculosis of lungs.		Pneumonia.		Other respiratory diseases.		All respiratory diseases.		All causes.	
	Number.	Per cent of deaths from all causes.	Number.	Per cent of deaths from all causes.	Number.	Per cent of deaths from all causes.	Number.	Per cent of deaths from all causes.	Number.	Per cent of deaths from all causes.
15 to 24 years	9	8.0	9	8.0	1	0.9	19	17.0	112	100.0
25 to 44 years	323	38.6	126	15.1	42	5.0	491	58.8	836	100.0
45 to 64 years	260	46.7	86	15.4	61	11.0	407	73.1	557	100.0
65 years and over	18	17.3	13	12.5	25	24.0	56	53.8	104	100.0
Age unknown	1	20.0	1	20.0	......	....	2	40.0	5	100.0
Total, 15 years and over	611	37.9	235	14.6	129	8.0	975	60.4	1,614	100.0

It is shown by this analysis that the proportion of deaths from pulmonary tuberculosis among the copper miners of Butte, Mont., is decidedly excessive.[1] It is of special significance that the proportionate mortality from this disease should be highest at ages 45 to 64. The data suggest that in all probability deaths are reported as due to pulmonary tuberculosis which, in fact, are more properly attributable to nontuberculous so-called miners' phthisis, or true silicosis. The proportionate mortality from pulmonary tuberculosis among the copper miners of Butte, Mont., increases very rapidly from 8 per cent at ages 15 to 24, to 38.6 per cent at ages 25 to 44, and to 46.7 per cent at ages 45 to 64. Even at ages 65 and over the proportion is as high as 17.3 per cent. In addition to the mortality attributed to pulmonary tuberculosis, the mortality from pneumonia is exceptionally high. The proportion of deaths from this cause increases from 8 per cent at ages 15 to 24 to 15.1 per cent at ages 25 to

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[1] An analysis of the general mortality of Silver Bow County, Mont., for the period 1911–1915, showed the following results:

For the city of Butte the death rate from pulmonary tuberculosis was 215.8 per 100,000 of population and from nontuberculous respiratory diseases 242.0. The facts were almost precisely the opposite for Silver Bow County, exclusive of the city of Butte (that is, only the rural portion), in which the death rate from pulmonary tuberculosis was 352.8 per 100,000 and from nontuberculous respiratory diseases 202.0. For the county as a whole the pulmonary tuberculosis rate was 227.3 and the mortality from nontuberculous respiratory diseases was 229.6. For the remainder of the State of Montana the mortality rate from pulmonary tuberculosis was only 75.4 and from nontuberculous respiratory diseases 112.4.

The data are, therefore, entirely conclusive that the mortality from both pulmonary tuberculosis and nontuberculous respiratory diseases is decidedly excessive in the city of Butte and in the surrounding territory comprising the remainder of Silver Bow County. The relation of this excess to the mining industry can not be questioned by anyone familiar with local industrial conditions.

44, remaining at about the same proportion, or 15.4 per cent, during the age period 45 to 64, and falling to 12.5 per cent at ages 65 and over. Aside, however, from pneumonia, there is an additional high proportionate mortality from other respiratory diseases, which reaches the maximum at ages 65 and over, or 24 per cent. Combining all forms of respiratory diseases, whether tuberculous or nontuberculous, it is shown by the table that at ages 15 to 24 the proportion of deaths from this group of causes in the mortality from all causes among the copper miners of the Butte district was 17 per cent, at ages 25 to 44 it was 58.8 per cent, increasing to a maximum of 73.1 per cent at ages 45 to 64, and attaining to 53.8 per cent at ages 65 and over. It seems, therefore, quite safe to conclude that this unusual condition is directly attributable to the exceptionally health-injurious nature of the dust inhaled during the underground mining operations in the Butte district, although with regard to pneumonia it should be said that climatic conditions, drinking habits, etc., have also an important bearing upon the question under consideration. The elevation of Butte, Mont., is 5,500 feet above sea level, and, as elsewhere observed, in localities at a high altitude the mortality from pneumonia is practically certain to be above the normal.[1] The question of altitude, however, is of quite secondary importance, for whenever the necessary sanitary improvements have been introduced into mining methods, housing, etc., and when the earlier conditions of riotous living have disappeared, the incidence of pneumonia will be substantially diminished. This has been the case throughout the western States, but especially in the mining camps of Butte, Mont., Leadville, Colo., and certain sections of Idaho and Nevada.

The problem is therefore more complicated than would appear to be the case upon preliminary consideration. No strictly scientific study has been made of the disease problem in connection with copper mining, but conditions in this respect are known to vary widely in the chief centers of copper production. Conclusions applicable to the copper-mining district of Butte would unquestionably be inapplicable in a measure to the copper-mining territory of northern Michigan. To a lesser extent differences in conditions are met with in the copper-mining States of Utah and Arizona.

The morbidity and mortality problems in copper mining obviously demand more qualified scientific consideration. The general mortality statistics may be more or less misleading on account of serious defects in death certification. Unfortunately, autopsies are very rare, and the clinical diagnosis of pulmonary tuberculosis is, as a general rule, not confirmed by the necessary bacteriological evidence. The problem of nontuberculous respiratory diseases in the mining districts is, in all probability, of equal if not even more serious importance than true pulmonary tuberculosis. The relative frequency of pneumonia and other nontuberculous respiratory diseases in the Butte mining district suggests strongly a definite connection between unusual employment conditions and a rapidly fatal form of acute infectious respiratory diseases. Maynard, in his work on "The Manifestations and Prevention of Pneumonia among the Natives on the Rand, Recorded from Tropical Areas," shows conclusively that most of the morbidity occurs during the first few weeks, and even days, after arrival. A somewhat similar experience has been had on the Isthmus of Panama, though, of course, without reference to mining. Gorgas, in his recommendations as to sanitation concerning employees of the mines on the Rand, made to the Transvaal Chamber of Mines, points out in this connection that pneumonia varies greatly in the different mines and among different classes of natives, and in accordance with other circumstances which do not admit of being discussed in detail on this occasion. Pneumonia, he observes, "is a disease in man due to infection by a particular organism—the pneumococcus. Individuals and races differ widely in the degree in which this organism affects them. The liability is most serious in the case of native races not previously exposed to the pneumococcus, and even slight colds, sore throat, etc., may be followed by fatal results." The bearing of these observations upon the problem of miners' phthisis and pulmonary tuberculosis is obvious. In other words, the mortality of miners may be, and occasionally is, materially increased by special conditions, chiefly such as result from exposure to other than infectious diseases, aside, however, from fatal accidents, which tend to disturb materially the proportionate mortality from specified causes.

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[1] See in this connection Professional Paper 74, United States Geological Survey, entitled "Geology and Ore Deposits of the Butte District, Montana," by Walter Harvey Weed; Washington, 1912.

The occurrence of chronic interstitial pneumonia, introduced by stone dust, has been discussed in a contribution to the Journal of the American Medical Association, under date of June 13, 1900, by Dr. William Winthrop Betts, of Salt Lake City, based apparently on extended metal-mining experience in Nevada and Utah. After describing a number of cases in detail·Dr. Betts gives some important facts regarding the rapidly fatal course of the disease among men employed for even a comparatively short time in the mills of the mining companies at De Lamar, Nev. He observes that "almost every town in Nevada and southern Utah has had its victim, for it is a fact that neither the company nor the men realized their danger until the deaths began to occur." The conclusion in this case was based upon a number of autopsies and a chemical and microscopical analysis of the tissues of the lungs and bronchial glands. The chemical examination of the lungs indicated the presence of pure silica to the amount of 2.8 per cent in the lung tissue and 3.8 per cent in the glands. Betts therefore advanced the conclusion that "the cases were more properly regarded as chronic interstitial pneumonia, which consists in the gradual substitution, to a greater or less extent, of connective tissue for normal lung"; and he concludes, further, that "The different conditions under which these changes occur are so varied that a proper classification is difficult, but the interstitial changes play a very important rôle in all chronic lung troubles. There is no sharp line of demarcation between fibrous phthisis and other forms of chronic pulmonary phthisis, and there are instances of fibrous phthisis which can not be distinguished from cirrhosis of the lung from other causes." Summarizing his conclusions, he states that, in the light of the clinical history of the cases under observation, and the results of autopsy examinations, including microscopical and chemical analyses, he has no hesitancy "in speaking of them as chalicosis pulmonum, or chronic interstitial pneumonia." The paper is an exceptionally valuable one, and the observations are amplified by a long list of individual cases of men who had died subsequently to their employment with continuous exposure to irritating dust, at an average age of only 30 years, although the average height was 5 feet 8½ inches and the average weight 170 pounds, which would suggest otherwise exceptionally favorable physical conditions. The average working time previous to the onset of the disease was only 14 months, and the average intervening period between the termination of work and death was only 10 months, or an aggregate exposure to conditions exceptionally injurious to health of only two years. (See also, p. 430 et seq.)

IRON MINING.

The iron-ore mining industry is of enormous extent throughout the United States, but it is chiefly concentrated in the four States of Minnesota, Michigan, Wisconsin, and Alabama. Of the aggregate output during 1915 the proportion of ore mined in these three States was 93 per cent. Iron minerals are differentiated by the United States Geological Survey as sulphides, oxides, carbonates, silicates, etc., of which only the oxides and the carbonates are used in the iron and steel industry, except a relatively small quantity of by-product from sulphide ores used in acid manufacture. It is explained that the ores of iron are generally classified as follows:

1. Hematite (locally known as red hematite), specular ore, gray ore, etc.
2. Brown ore, locally known as brown hematite, bog ore, limonite, etc.
3. Magnetite, generally known as magnetic iron ore.
4. Iron carbonate, locally known as spathic iron ore, siderite, etc.

Of these four varieties hematite ore constituted 94 per cent of the American output for 1915, or precisely 52,227,324 tons out of a total quantity of 55,526.490 tons. Brown ore constituted only 2.7 per cent of the total, or 1,488,709 tons; and magnetite 1,807,002 tons, or 3.3 per cent. The carbonate product is very small, amounting to only 3,455 tons in 1915. Most of the hematite ore—46,944,254 tons out of a total of 52,227,324 tons—is mined in the Lake Superior district. Most of the brown ore is mined in the Appalachian States and most of the magnetite ore in the Adirondack district of the State of New York.[1]

The methods of mining vary according to the nature of the ore mined, geological formations, and other conditions, but the major portion of the product is obtained by open-pit mining, although underground iron mining involving all the usual underground processes is not at all rare. In open-pit mining the dust exposure is obviously much less than in underground mining, so that for this reason alone the health of iron miners should, in a general way, be less seriously affected by the occupation than that of gold, silver, copper, lead, zinc, and other miners, who are chiefly and almost exclusively employed underground. The number of iron miners in the United States is returned by the Bureau of Mines for the year 1914 as 44,807, of whom 24,847, or 55.5 per cent, work underground, which compares with 73.1 per cent for gold, silver, and miscellaneous metal mines, and 70 per cent for copper mines. The fatality rate in iron mining in 1914 was relatively high, or 3.3 per thousand, which compares with 3.7 for gold and miscellaneous metal mines, and 3.69 for copper mines. No qualified investigation has been made into the health and mortality of iron miners considered separate and distinct from the mining industry in general, and on account of the extensive development of open-pit mining methods in the United States the conclusions of Arlidge and others, based largely upon underground iron mining in England and on the Continent, are of doubtful applicability to American conditions. Iron ores in England are called ironstone, and the ore is mined from considerable depths, while in the United States iron ore, particularly the red hematite, is mined more largely from shallow excavations in the nature of open quarries than by mining methods properly so called. It is therefore regrettable that there should be no conclusive vital statistics of iron miners for this country, although a sufficiently extensive experience has been had in the principal mining districts which, if subjected to qualified analysis, should prove useful for the purpose. The Port Henry iron mines in the State of New York, for illustration, have been in operation since 1849, but thus far no qualified medical inquiry has been made with regard to the relation of iron mining in this country to health and longevity. There are, however, no reasons for believing that the metallic content of iron ore has an important bearing upon the health aspects of the industry, since the relative frequency of fibroid phthisis and true pulmonary tuberculosis are more directly determined by the nature of the ore mined, which of course is chiefly composed of mineral matter and from which the metallic substances are extracted by subsequent processes of smelting and refining.

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[1] See New York State Museum Bulletin 119 (Education Department Bulletin 423, Albany, N. Y., April, 1908), entitled "Geology of the Adirondack Magnetic Iron Ores," by David H. Newland.

Subject to the foregoing considerations it has not seemed advisable to omit from this discussion the vital statistics of ironstone miners for England and Wales, which, however, do not require an extended analysis. Table 132 shows the mortality of ironstone miners in England and Wales (occupied only) for the three years, 1900 to 1902, by divisional periods of life, and Table 133 shows the mortality from other respiratory diseases, but without reference to age.

TABLE 132.—PROPORTIONATE MORTALITY OF IRONSTONE MINERS (OCCUPIED ONLY) FROM PULMONARY TUBERCULOSIS, ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[Source: Part II, Supplement to the Sixty-Fifth Annual Report of the Registrar General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent of deaths from all causes.
15 to 24 years	36	8	22.2
25 to 34 years	70	16	22.9
35 to 44 years	69	15	21.7
45 to 54 years	105	17	16.2
55 to 64 years	135	18	13.3
65 years and over	148	3	2.0
Total, 15 years and over	563	77	13.7

TABLE 133.—PROPORTIONATE MORTALITY OF IRONSTONE MINERS FROM NONTUBERCULOUS RESPIRATORY DISEASES, ENGLAND AND WALES, 1900 TO 1902.

[Source: Part II, Supplement to the Sixty-fifth Annual Report of the Registrar General of Births, Deaths, and Marriages in England and Wales.]

Cause of death.	Deaths from nontuberculous respiratory diseases.	
	Number.	Per cent of deaths from all causes.
Bronchitis	36	6.4
Pneumonia	43	7.6
Other nontuberculous respiratory diseases	20	3.6
Total	99	17.6
Accidents	81	14.4

According to Table 132, the proportionate mortality from pulmonary tuberculosis is relatively low among ironstone miners—13.7 per cent for all ages and 22.9 per cent for ages 25 to 34. The number of deaths under observation is, however, rather small for safe conclusions. As shown in Table 133, the mortality from nontuberculous respiratory diseases is 17.6 per cent, the proportion of deaths from bronchitis being 6.4 per cent, from pneumonia 7.6 per cent, and from other respiratory diseases 3.6 per cent. These proportions would be slightly modified by the inclusion of the retired, but it would serve no useful purpose to enlarge upon this aspect of the problem under consideration, since most of the comparative statistics in the present discussion have reference only to the occupied, or, in other words, the mortality considered represents the occupations at death, and, broadly speaking, as a rule, excludes the mortality of men previously occupied in given occupations, or subsequently occupied in less harmful occupations, or retired on account of invalidity or old age.

The relatively high mortality from nontuberculous respiratory diseases suggests the inclusion of Table 134, showing the mortality of ironstone miners from bronchitis, pneumonia, and other respiratory diseases in detail by divisional periods of life.

TABLE 134.—PROPORTIONATE MORTALITY OF IRONSTONE MINERS (OCCUPIED ONLY) FROM NONTUBERCULOUS RESPIRATORY DISEASES, ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[Source: Part II, Supplement to the Sixty-fifth Annual Report of the Registrar General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Deaths from all causes.	Deaths caused by nontuberculous respiratory diseases.							
		Bronchitis.		Pneumonia.		Other.		Total.	
		Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
15 to 24 years	36	......	......	2	5.6	......	......	2	5.6
25 to 34 years	70	......	......	5	7.1	4	5.7	9	12.9
35 to 44 years	69	1	1.4	5	7.2	4	5.8	10	14.5
45 to 54 years	105	9	8.6	17	16.2	5	4.8	31	29.5
55 to 64 years	135	12	8.9	9	6.7	3	2.2	24	17.8
65 years and over	148	14	9.5	5	3.4	4	2.7	23	15.5
Total, 15 years and over	563	36	6.4	43	7.6	20	3.6	99	17.6

The foregoing statistics are of special interest in comparison with the corresponding data for English coal miners, which are distinctly more favorable for pulmonary tuberculosis, but less favorable for nontuberculous respiratory diseases, particularly bronchitis. As brought out by the discussion of the mortality of coal miners, the proportion of deaths from bronchitis among them in the English experience was 9.5 per cent against 6.4 per cent for ironstone miners.

How far these observations and conclusions apply to the underground mining of the United States can not be determined at the present time. No insurance data are available, chiefly because of the fact that the operations of the industrial insurance companies in the principal iron-mining districts are of rather limited extent. There are also reasons for believing that many iron miners return themselves merely as "miners" in the statement relating to their occupation and that they are subsequently classified under the mining industry in general.

A small group of iron mines of rather limited production has been in operation for many years in New Jersey, and the results of an investigation by the New Jersey Bureau of Labor in 1890 with reference to trade life and occupational disability may briefly be referred to. The investigation included 1,269 miners of all ages, of whom 43.1 per cent had entered the employment at ages under 16 years. Of the 1,269 only 39, or 3 per cent, had attained to the age of 61 and over, and 79, or 6.2 per cent, were of the age period 51 to 60. The proportion of foreign born was 60.4 per cent, but it is practically certain that at the present time this proportion is larger. The average number of years at work was 16.0, varying, of course, according to the ages attained. At ages 61 and over the average previous duration of mine employment was 42.8 years. But conclusions based upon such data require for practical purposes to be utilized with extreme caution, in that a number of factors enter into the calculation which can not be adequately explained with the required brevity. It is much the same problem in trade life as in life generally, that the average age at death is not the mathematical equivalent of the average age of the living, on the one hand, nor of the expectation of life on the other. The effects of the employment on health are indicated by the proportion of those beginning to decline in physical strength, which for the present purpose may be considered the equivalent of physical good health. The proportion at ages under 26 beginning to decline was 1.1 per cent, increasing with age, as follows: At ages 26 to 30 the proportion beginning to decline was 1.5 per cent; at ages 31 to 40 it was 2.3 per cent; at ages 45 to 50 it was 3.4 per cent; at ages 51 to 60 it was 48.1 per cent; and at ages 61 and over it was 74.4 per cent. At the younger ages, that is, under 50, the numbers beginning to decline were relatively so small as not to justify any very definite conclusions, but the data apparently sustain the point of view that no materially health-injurious results were experienced below the ages of 51. Above this age, of course, other factors and conditions would materially affect general health and physical strength, so that the proportion beginning to decline is not in its entirety chargeable against the industry of the entire number considered, 1,269, the number beginning to decline being 90, or 7.1 per cent. The average duration of work previous to decline was 21.8 years. The New Jersey investigation with reference to the average duration of trade life and the ascertained period of physical decline strongly suggests the practical possibility of further research in this much neglected direction. The data indicate in a general way that iron mining in the State of New Jersey was not seriously injurious to health or the obvious cause of an early impairment in physical strength and ability to work.

The health conditions of American iron miners were investigated by the United States Immigration Commission, and reported upon in a general survey of the iron-ore mining industry, chiefly with reference to the States of Minnesota, Michigan, and Alabama. The working conditions were inquired into with reference to mining methods and class of labor employed in the several systems of mining on the Mesabi Range, the hours worked per day, the regularity of employment, wage payment, mining accidents, hospital and medical service, company accident insurance, etc. The ores on the Vermillion Range, which are all of the hematite class, are in all instances very hard, and "underground mining is necessary to remove the ore, which lies often at a great depth below the surface, some of the shafts having been pushed over a thousand feet underground." Two systems of underground mining are employed, known technically as the "overhand stoping" and the "caving" methods, which can not be conveniently explained with the required brevity. The differences in underground mining methods are of more direct importance, however, with reference to accident liability than to health and mortality. It is pointed out in the report referred to that "the ore is so hard at places that percussion drilling has been displaced by the introduction of diamond drills for use in making blast borings." In marked contrast to the conditions on the Vermillion Range the open-pit method of mining prevails extensively on the Mesabi Range. The open-pit system, or mining by steam shovels in open-surface cuts, consists, as explained in the report, "in removing the glacial drift or 'overburden' which covers the ore beds, varying from a few feet to about 80 feet in thickness, by the use of steam shovels and then securing the iron ore by the same methods." Quoting from a special monograph on the Mesabi Range by the United States Geological Survey, it is said further, with reference to mining methods, that—

> When the surface of the ore or a part of it is stripped, standard-gauge railroad tracks are built out on the ore deposit and steam shovels make a cut through the ore. In this first cut the ore is either thrown to one side or is loaded on cars brought on a paralleled track. After the first cut the shovel is set over against the bank and another slice is taken off and loaded onto the cars run into the cut already made. When by a series of slices or cuts the bank or bench

or level is carried back far enough, work is begun as before on a lower level, and in time this is followed by cuts on third and fourth levels, carving the deposit into a series of banks or terraces at several levels, against any or all of which steam shovels may work, giving access to a great variety of ores and making possible a large output in a short time.

These extracts are sufficient for the purpose of emphasizing the practical difficulties of averaging iron-mining conditions so as to make general vital statistics concerning iron miners useful for scientific purposes. It is self-evident that conclusions based upon iron miners, so called, working largely above ground and employed chiefly in open-cut blasting operations or the management of steam shovels, etc., can not be made to apply to miners working continuously underground with an exposure of dust and other conditions quite similar to underground mining methods in the extraction of gold, silver, copper, lead, and other ores. The so-called "milling" process as practiced on the Mesabi Range may here be referred to, the same being explained in the report of the Immigration Commission to consist "in the sinking of a shaft on the edge of the ore body from which a tunnel is run in under the ore and connected with a vertical, funnel-shaped hole from under the surface, through which the ore is 'milled' down into the tramcars placed under the opening under the tunnel. After being loaded at the bottom of the funnel-shaped hole, the cars are run out to the bottom of the shaft, where the ore is dumped into skids or elevators and raised to the surface and unloaded into the tipple, where it is loaded into the cars ready for shipment." It is properly pointed out that the so-called "milling" process employs some of the features of both the open-pit and underground methods of mining. For these and many other reasons it is self-evident that general statistics concerning iron mining are quite likely to be inconclusive and possibly seriously misleading.

Aside from the foregoing the problem is seriously complicated by the extensive employment of foreign labor in the iron-mining industries of the Lake Superior districts and of Negro labor in iron mining in Alabama. Within recent years, according to the report of the Immigration Commission, a considerable displacement has occurred in the quality of labor employed in iron mining, the displacement being referred to as "progressive," in that one race or group of races has entered the region and taken up the work offered in the lower occupations, the race or races already holding such positions having moved up in the scale of occupation leaving the field to the newcomers. This statement is quite suggestive in that it indicates a comparatively short average trade life or trade exposure, quite at variance with the relatively long average ascertained for the iron mines of New Jersey. It is said in the report of the Immigration Commission that—

> The Scandinavians and the other northern European races have given way to the Finns and Slovenians, and in the open-pit mines the Finns and Slovenians have given way to the south Italian, Montenegrins, Croatins, and other southern European races. In the underground mines the common labor and mining is chiefly done by Finns and Slovenians because the races from the southern countries can not stand the heavy physical work required in this kind of mining. Here, too, is found the same upward movement, for formerly the English (Cornishmen) and Scandinavians were in the lower occupations in the underground properties. At present the south Italians, Serbians, Montenegrins, and Croatians are performing the most menial work and are the races who are now at the foot of the scale of occupations. It is a matter of conjecture on the ranges as to who will push these races up or whether they will remain the common laborers of the region.

Inquiry was made into the prevalence of diseases on the ranges, but more with reference to outside sanitary conditions than to occupational exposure. The most common diseases on the ranges, however, were ascertained to be pulmonary tuberculosis and typhoid fever, and to a lesser extent smallpox and venereal diseases. With regard to pulmonary tuberculosis it is said that the disease is most prevalent among the Finns and the Swedes, and is chiefly imported. There is no reference to a possible connection between disease occurrence and occupational conditions, above or below ground, but there is no evidence that this aspect of the iron-mining industry was made the subject of a special investigation.

COAL MINING.

The coal-mining industry of the United States during 1914 gave employment to about 763,000 persons, chiefly in the States of Pennsylvania, West Virginia, Ohio, and Illinois. The fatality rate in American coal mining is relatively high, or 3.22 per 1,000 employed for the year 1914, which, however, was below the average for the preceding decade. Largely in consequence of the persistent efforts of the United States Bureau of Mines, in cooperation with State mine inspectors, mine owners, and mine employees, a gradual improvement has been brought about in the conditions affecting both the calamity hazard and the individual liability of miners to fatal accidents and serious injuries. Thus far, however, no extended consideration has been given to the sanitary aspects of the industry, with reference both to conditions underground and on the surface, including the hygiene of mining towns, which is often decidedly unsatisfactory. The fatality rates vary widely in the different mining fields, largely in consequence of variations in underground conditions, which also, though probably to a lesser degree, affect the health of employees.

Whether one form of coal dust is distinctly more injurious to health than another has not been accurately determined. The dust itself is frequently pure carbon, but there are many important exceptions where the dust is considerably intermixed with other mineral and even metallic impurities.

In coal mining a relatively large proportion of the employees are not engaged in mining operations proper, the term "miner" being generally limited, in accordance with State certificates, to men who drill holes and blow down the coal by explosives, and to the mine laborers who assist the miners in drilling the holes and loading the loose coal into mine cars. As stated in an article in the Coal Age (1915), of 96,991 men returned as employed in connection with the anthracite coal industry of Pennsylvania. 44,346 were returned as miners, and 33,973 as mine laborers. It has also been stated that there are nearly 100 different positions or specified employments in the coal-mining industry, with an exceedingly confusing terminology, including many occupations, such as carpenters, machinists, electricians, etc., which are identical with employments carried on above ground and without reference to the mining industry. Most of the coal, of course, is mined in the proper sense of the term, underground, but within recent years some coal stripping operations have been developed, which give employment to an increasing proportion of men. Primitive methods of mining by pick and shovel have largely been replaced by coal-cutting machinery, which has apparently resulted in an increase in the dust contamination of the atmosphere. The problem is further complicated by the exceptionally large proportion of foreign-born laborers usually without previous mining experience and frequently of an intellectual status materially below the average American standard. Conformity on the part of this class of labor to exacting sanitary requirements is naturally enforced with difficulty even in the best-managed mines. On account of the extensive use of coal-cutting machinery the technical requirements for underground work are apparently less at the present time than in former years, so that the term "miner," with special reference to coal, has lost much of its former restricted significance. The far-reaching improvements in labor conditions, however, the shorter hours, the higher wages, the better conditions of housing, etc., have gone far toward causing an improvement in general health and a reduction in the general mortality, although underground conditions have remained practically about the same. The increasing dust hazard as a cause of disastrous dust explosions has been recognized by conservative mine managers, and many effective improvements have resulted in consequence of attention to economic considerations without specific reference to sanitary necessities. Physical selection has unquestionably operated distinctly in favor of a low death rate since for self-evident reasons the physically impaired or otherwise weak or infirm could not be employed at arduous labor underground.[1] According to Dr. F. J. Butler, of Wilkes-Barre, who testified before the Anthracite Coal Commission of 1902, he had in many cases found on post-mortem that lungs affected by miners' asthma were so heavily charged with dust particles that they sank when immersed in water, while the healthy lungs, by way of contrast, he took occasion to point out, would float without difficulty. Dr. John O'Malley, of Scranton; Dr. F. P. Lenahan, of Wilkes-Barre; and Dr. R. H. Gibbons, of Scranton, presented evidence on the basis of extended experience in mining communities, to the effect that special diseases prevailing among coal miners were miners' asthma, catarrh, consumption, rheumatism, and anemia. Miners' asthma was attributed in part to the inhalation of powder smoke, coal dust, and vitiated air. According to Dr. O'Malley, the mucous membrane of the lungs becomes saturated with coal dust and acts as an irritant, causing muscular contraction of the lungs. On post-mortem the lungs were found to be as black as anthracite coal. Rheumatism was common and the pneumonia observed to exist in many cases was evidently a factor in diminishing disease resistance generally.

In a brief discussion of foreign vital statistics in the Journal of the American Medical Association for December 6, 1902, in commenting upon the very limited American data, it is pointed out that in a general way "the statistics are distinctly favorable to the miners." The editorial includes a quotation from Newsholme's Vital

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[1] It may seriously be questioned whether the general assumption that coal miners are a physically selected class is strictly in conformity to the facts. There has been no extended scientific inquiry into the subject, and, as far as known, the only available data are those derived from the ordinary mortality experience of The Prudential Insurance Co. Whether even these data are entirely conclusive may be questioned, in view of the fact that they relate only to coal miners who have died, and not to the living population. The data, however, would seem to be strictly comparable with the corresponding information for printers, presented elsewhere in this discussion. The data in detail are given in the table below, and are indicative of the physical inferiority of insured coal miners at ages 35 to 64, inclusive, in the manner that the height or weight, and the relative weight, of this class is, without exception, below the average for all males:

Coal Miners—Males.

[Prudential Ordinary Experience, 1886 to 1915.]

Age at entry.	Number.	Average height (inches).	All males.	Average weight (pounds).	All males.	Relative weight (pounds per inch).	All males.
15 to 24 years	97	67.8	68.1	146.7	144.7	2.16	2.12
25 to 34 years	201	68.4	68.3	157.6	154.5	2.30	2.26
35 to 44 years	240	67.5	68.1	155.1	160.2	2.30	2.35
45 to 54 years	205	67.8	67.9	157.1	162.8	2.32	2.40
55 to 64 years	31	67.0	67.8	151.4	162.7	2.26	2.40
65 years and over	1	67.0	67.9	165.0	161.8	2.46	2.38
Total	775	67.8	68.1	155.1	156.6	2.29	2.30

Statistics to the effect that coal miners in Derby and Nottinghamshire stand high in the list as to expectation of life, being only surpassed by farmers, agricultural laborers, teachers, etc., but in Lancashire their status is quite different, and that the variations in the death rate are in all probability due to other causes than the employment. Attention is directed to the fact that one of the principal diseases among coal miners in the United Kingdom is bronchitis, while the corresponding frequency of phthisis is relatively slight. In conclusion it is said that, taking it altogether, the facts collected from all sources seem to indicate, what could hardly have been expected, that the occupation of coal mining was neither relatively nor absolutely unhealthy, as compared with other means of gaining a livelihood. It has its inconveniences and hardships, and is exposed to special dangers from accidents, but these can be minimized by proper care, appliances, and legal regulations. The special diseases to which miners are liable seem to be largely preventable, and greater care in changing from the equable atmosphere of the mine to the extremes of heat and cold outside would probably reduce the proportion of respiratory affections, such as asthma, etc., that are now claimed to be incident to the occupation. The official statistics of miners as a class include so large a number of different occupations that, as elsewhere shown with reference to community mortality data, the special facts of a particular group of exceptionally unhealthy employments may be obscured.[1]

Of the total number of men employed in American coal mines, 83.8 per cent work underground; of this proportion the actual number of men employed at the breast of the mine, where the dust hazard is serious, is about 73 per cent. Mining conditions, as said before, are subject to an unusual degree of variation, as to whether, for illustration, the mining is by hand or by machinery; as to whether the dust is anthracite or bituminous; as to the character of the underlying and overlying strata, etc. That pulmonary tuberculosis is relatively less common among coal miners than among metal miners admits of no question of doubt. The important differences are chiefly attributable to the mechanical and chemical properties of the dust inhaled. It has frequently been maintained that the dust in coal mines has germicidal properties antagonistic to the development of pulmonary tuberculosis, but the evidence at present available is not conclusive. In a letter to the Journal of the American Medical Association, December 16, 1905, Dr. M. C. Carr, of Duquoin, Ill., states that, on the basis of an experience of 25 years in one of the largest coal-mining towns in southern Illinois, in his opinion "bituminous coal miners while actively engaged in their occupation are practically immune from tubercular infection."[1] For the purpose of ascertaining the consensus of qualified medical opinion on the subject, he sent out a letter to some 600 practicing physicians in the coal-mining towns of Illinois, Indiana, Ohio, Pennsylvania, and West Virginia, and out of some 200 replies received about 75 sustained the point of view that "during active service in his occupation the bituminous coal miner is immune (to tuberculosis), wholly or in part." The conclusion is obviously a very broad generalization, and merely referred to here as an indication of the superficial nature of most of the inquiries which have thus far been made with reference to an exceedingly important question in occupational hygiene. It is self-evident that as a general principle men would not be found to suffer from pulmonary tuberculosis while actively employed, for, as elsewhere shown in the case of a life insurance agent with eight years' experience, the disease had been contracted during prolonged previous experience in mining in England and the Transvaal. (See p. 345.) If the previous mining experience had been ignored, the conclusion apparently would have been sustained by the evidence that the disease had been contracted in the pursuit of one of the most healthy outdoor employments.

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[1] For a descriptive account of the principal employments in coal mines see discussion of "Fatal Accidents in Coal Mining," by F. L. Hoffman, Bulletin No. 90, U. S. Bureau of Labor, Washington, 1910.

According to the general vital statistics for England and Wales the mortality from pulmonary tuberculosis in that country is distinctly less than in the United States, while the mortality from bronchitis in its various forms is seriously excessive.[2] These facts must be taken into account in interpreting such terms as miners' asthma and miners' bronchitis, which is frequently quite indistinguishable from ordinary bronchitis, although usually recognized without difficulty in the more advanced stages of the disease. Ogle, in an address before the Seventh International Congress of Hygiene (Vol. X, p. 22), placed on record his conclusions, resting upon perhaps the largest available amount of statistical evidence, that—

> Now that coal dust should be less injurious to the lungs than the dust of stone or metal is readily intelligible for, as Hirt has pointed out, the particles of coal when examined under the microscope are found to be, comparatively speaking, rounded off and free from

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[1] A large amount of extremely valuable information on the technical aspects of coal mining in the State of Illinois has been made available through the coal-mining investigations of the State Geological Survey under a cooperative agreement between the Engineering Experiment Station of the University of Illinois and the United States Bureau of Mines. These investigations include, for illustration, a chemical study of Illinois coal (1916), a descriptive account of coal-mining practice in every mining district of the State, a general account of coal mining, and the different coal seams, etc.

[2] The essential facts of the comparative mortality from tuberculosis and nontuberculous respiratory diseases are concisely set forth in a series of charts presented by The Prudential Insurance Company of America to the Royal Sanitary Institute of Great Britain and to the Henry Phipps Institute of Philadelphia. Miniature reproductions of these charts are available on application to the company.

sharp points and angles such as characterize the flint dust in a china factory. This, however, clearly would only explain why coal miners are less subject to these diseases than workers in metal and stone, and not why they are scarcely more subject to them, taken together, than agricultural laborers, nor why their mortality from phthisis alone is very little above that of fishermen, who have been taken as the standard of comparison, because of their healthiness. The figures given in my table, supported as they are by the consentient evidence of all those who have personal experience of the diseases of miners, leaves no possible doubt that for some reason or other coal miners are much less liable to phthisis than most other workmen, and that, even as regards lung diseases generally, their liability is by no means so great as is usually supposed.

Louis, in a more recent contribution to Oliver's Dangerous Trades, has advanced similar conclusions, observing that "It may first of all be stated that mining is a distinctly healthy occupation." He remarks further that—

> There are no doubt several circumstances that contribute to the general healthiness of the miner's occupation; in the first place, mining is hard work, and men whose constitutions are not tolerably sound, and whose physiques are not fully up to the average, will either select some less arduous occupation at the outset, or will find themselves, if they began life as miners, unable to continue at the work. On the other hand, the work, though arduous, requires steady, though only moderate exertion, and does not expose the worker to the abnormally violent strains, exerted through brief periods, that characterize some other occupations. Again, the hygienic conditions are, as far as the coal mine at least is concerned, far more favorable than in most other occupations. The miner works in a good atmosphere, ample ventilation being a prime necessity for insuring the safety of the coal miner, in an equable temperature, free from the extremes of heat and cold, he is not exposed to the inclemencies of the weather, and his working place is usually dry.

The foregoing observations, according to Louis, can not, however, be made to apply to metalliferous mines, where "the conditions of work are far less favorable in every respect," and where the mortality is therefore higher. He directs special attention to the so-called "kirving" or undercutting of the coal, as being particularly unhealthy in that the miner has to lie on his side on the floor of the coal seam, swinging his pick with a peculiar sideways stroke over his head, till he has cut out a narrow groove some 3 feet deep below the overhanging mass of coal. The health-injurious effects, however, are chiefly with reference to the causation of miners' nystagmus. This method of mining is rather uncommon in the United States where coal cutting by machinery is now the general practice. While in this position, Louis states, by way of further explanation, "the coal miner is bound to inhale a considerable amount of fine coal dust, which has an irritating effect upon the lungs," and he includes a brief analysis of the mortality of coal miners by causes, according to which 16.2 per cent of the deaths were from accidents, 10.7 per cent from phthisis, 12.4 per cent from bronchitis, and 10.9 per cent from pneumonia. As a method of relief he suggests the use of mechanical coal cutters, which, of course, as is well known, are used almost universally in the United States. By way of contrast Louis directs attention to the higher mortality of metal miners, including the men employed in the Cornish tin mines, the method of which is considered typical of metal-mining methods in Great Britain. Phthisis, he observes, is extremely fatal among this class of employees, and bronchitis is also excessively common. Of the mortality during 1890–1892, 5.8 per cent of the deaths were caused by accident, 29.9 per cent by phthisis, 13.5 per cent by bronchitis, 5.4 per cent by pneumonia, and 7.1 per cent by other diseases of the respiratory system.

MORTALITY OF MINERS IN THE UNITED KINGDOM.

On account of its numerical importance in the United Kingdom, the official vital statistics of the mining industry for the three years. 1900–1902, are of exceptional value, although their application to American conditions is naturally more or less restricted. Out of an aggregate of 637,590 men employed in the mining industry, 609,402 were employed in coal mining, 16,765 in ironstone mining, and the remainder in the mining of copper, tin, and lead. The metalliferous mining industries are, therefore, of relatively small importance. The comparative death rates of the different branches of the mining industry, compared with those of occupied and retired males represented by 100 for each divisional period of life are shown in Table 135.

TABLE 135.—MORTALITY OF MINERS COMPARED WITH THAT OF OCCUPIED AND RETIRED MALES, GREAT BRITAIN AND IRELAND, 1900 TO 1902, BY AGE GROUPS.

[Source: Part II, Supplement to the Sixty-fifth Annual Report of the Registrar General of Births, Deaths, and Marriages in England and Wales.]

	15 and under 20 years.	20 and under 25 years.	25 and under 35 years.	35 and under 45 years.	45 and under 55 years.	55 and under 65 years.	65 years and over.
Occupied and retired males	100	100	100	100	100	100	100
Mining industry	130	100	82	75	82	108	121
Coal miner	130	100	81	73	81	107	121
Ironstone miner	125	67	85	64	66	82	81
Copper miner	380	....	232	211	113	148	93
Tin miner	61	123	212	250	205	194	148
Lead miner	250	107	117	118	94	144	176

Supplementing these interesting statistics of the mortality from all causes, Table 136 exhibits the mortality from specified causes. Unfortunately the more important nontuberculous diseases of the respiratory system are not specifically returned.

TABLE 136.—MORTALITY OF MINERS COMPARED WITH THAT OF OCCUPIED AND RETIRED MALES, GREAT BRITAIN AND IRELAND, 1900 TO 1902, BY CAUSES OF DEATH.

[Source: Part II, Supplement to the Sixty-fifth Annual Report of the Registrar General of Births, Deaths, and Marriages in England and Wales.]

	All causes.	Influenza.	Alcoholism and disease of the liver.	Cancer.	Phthisis.	Diseases of the nervous system.	Diseases of the circulatory system	Diseases of the respiratory system.	Bright's disease.	Accident, with plumbism.	Suicide.
Occupied and retired males	100	100	100	100	100	100	100	100	100	100	100
Mining industry	89	92	51	78	53	83	91	113	63	207	58
Coal miner	88	88	51	78	48	84	92	111	66	208	58
Ironstone miner	74	104	58	75	67	51	64	79	23	200	32
Copper miner	166	......	105	50	307	80	23	422	......	......	......
Tin miner	212	104	28	101	436	84	105	419	143	92	32
Lead miner	120	121	58	97	173	69	111	155	54	127	32

In explanation of the preceding two tables it is said in the official report that—

In the mining industry as a whole the death rate of men under the age of 20 years exceeds by 30 per cent the standard for occupied and retired males. At ages 20 to 25 the mortality is normal, but from ages 25 to 55 it is below the standard, being in defect by no less than 25 per cent at ages 35 to 45. After the age of 55 the mortality of miners is again in excess. In the main working period of life the comparative mortality figure is 896, or 11 per cent below the standard, notwithstanding the excessive mortality from accident, which is more than twice the normal. Miners appear to suffer more heavily than the average from diseases of the respiratory system, but on the other hand the mortality from phthisis is little more than half the standard, as is also that from alcoholism and liver disease and from suicide. The mortality from influenza, cancer, diseases of the nervous and circulatory systems, and Bright's disease is likewise below the standard.

It may be stated in this connection that during the later triennial period under review the mortality of miners declined approximately 20 per cent in comparison with a corresponding decrease of 16 per cent in the mortality of occupied males generally. The decline affected all principal causes excepting cancer. With special reference to coal miners it is said that they constitute nine-tenths of the entire mining population, but that in view of the wide variations in local mortality rates the conditions should be considered in detail for the six principal coal mining districts.[1] The local mortality rates from both disease and accident are shown in Table 137.

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[1] For observations on the mortality from cancer with special reference to malignant lung diseases, see "Mortality from Cancer Throughout the World," by F. L. Hoffman, Newark, N. J., 1915, p. 56 et seq.

TABLE 137.—MORTALITY FIGURES FROM DISEASE AND FROM ACCIDENT AMONG COAL MINERS, IN SPECIFIED LOCALITIES OF GREAT BRITAIN.

[Source: Part II, Supplement to the Sixty-fifth Annual Report of the Registrar General of Births, Deaths, and Marriages in England and Wales.]

	Total mortality.	Disease.	Accident.
All coal miners:			
1900–1902	846	723	123
1890–1892	1,068	905	163
Coal miners in Lancashire:			
1900–1902	1,006	875	131
1890–1892	1,236	1,057	179
Coal miners in Monmouthshire and South Wales:			
1900–1902	951	782	169
1890–1892	1,322	1,041	281
Coal miners in Staffordshire:			
1900–1902	846	728	118
1890–1892	1,100	943	157
Coal miners in West Riding:			
1900–1902	783	684	99
1890–1892	1,051	920	131
Coal miners in Durham and Northumberland:			
1900–1902	763	658	105
1890–1892	894	783	111
Coal miners in Derbyshire and Nottinghamshire:			
1900–1902	675	595	80
1890–1892	841	737	104

According to this table, there has been a decline in the liability to accident in every coal-mining district and also a corresponding decline in the mortality from disease. Aside from an increase in the mortality from cancer in every mining district, there has also been an increase in nervous diseases and an increase in urinary diseases in the districts of Lancashire and in the West Riding of Yorkshire.

These tables are self-explanatory and require no further consideration. Table 136 shows an apparently low degree of susceptibility to pulmonary tuberculosis, while indicating a high proportionate mortality from nontuberculous respiratory diseases combined. There are convincing reasons for believing that a corresponding analysis of trustworthy American statistics for carefully selected coal-mining districts would yield approximately similar results; in other words, the mortality problem in the coal-mining districts is primarily one of nontuberculous respiratory diseases rather than of pulmonary tuberculosis. The acceptance and practical use of any and all of these observations and conclusions are subject to a very cautious interpretation of the statistical data, in view of the relatively high mortality from accidents at the most important divisional period of life.

The English statistics have not been subjected to the required critical analysis to bring out the remarkable degree of divergence in the local frequency rates of tuberculous and nontuberculous respiratory diseases. Sir Thomas Oliver in his most recent discussion on "Dust diseases of the lungs" in Kober and Hanson's Diseases of Occupation and Vocational Hygiene (New York, 1916), observes that, "so far as coal miners' phthisis is concerned, it may be stated that a collier who develops anthracosis may live for years and be little inconvenienced by his malady," but "this applies only to the man who has worked in soft coal. It is otherwise if the coal has been of a hard, gritty, and stonelike nature." It is only within the last few years that trustworthy comparative data have been made public regarding the microscopic analysis of coals in the different coal fields, and the results are quite conclusive that the chemical and mechanical properties of the dust vary considerably and particularly as to the proportion of mineral and even metallic impurities. General conclusions with regard to the mortality and disease liability of coal miners with special reference to pulmonary tuberculosis and nontuberculous respiratory diseases, therefore, should be made use of with extreme caution, for what may be true of the industry in general may be far from true for particular coal fields, where special conditions affecting health and life may vary decidedly from the normal. In some coal samples, for illustration, the proportion of fixed carbon may be as high as 90.75 per cent (Ehrenfeld mine, Cambria County, Pa.) or as low as 49.95 per cent (San Coulee mine, Cascade County, Mont.).[1] Similar variations are met with in the proportion of sulphur which is commonly present in coal in the form of iron pyrites, either in large lumps and bands or finely disseminated particles. Sulphur may also be present in combination with lime and magnesia as sulphates. The presence of other mineral and even metallic impurities may so completely modify the chemical and mechanical properties of fine coal dust as to produce widely different pathological effects on the lungs of miners subject to its continuous inhalation.

It is only upon the ground of the preceding considerations that the wide range in the mortality rates from pulmonary tuberculosis and nontuberculous respiratory diseases in the more important coal fields for which the information has been made available can be explained. The official English statistics are for six representative coal fields, and the results are shown in detail in the following series of tables, commencing with the consolidated table for all coal miners, but differentiating occupied miners only and occupied and retired miners (the term miners being used in the general sense as equivalent to all employees in the mining industry) for the six mine fields of Durham and Northumberland, Lancashire, West Riding, Derbyshire and Nottinghamshire, Staffordshire, and Monmouthshire and South Wales. The tables include, aside from the proportionate mortality data for pulmonary tuberculosis, the mortality from accidents, and each table is followed by an additional table showing in detail the nontuberculous respiratory mortality by divisional periods of life.

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[1] See Bulletin 22, U. S. Bureau of Mines.

TABLE 138.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG COAL MINERS (OCCUPIED ONLY), ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

Age at death.	Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent of deaths from all causes.
15 to 24 years	2,332	430	18.4
25 to 34 years	2,522	467	18.5
35 to 44 years	2,645	364	13.8
45 to 54 years	3,295	331	10.0
55 to 64 years	3,866	198	5.1
65 years and over	4,195	49	1.2
Total, 15 years and over	[1] 18,855	1,839	9.8

[1] Including 2,806 deaths from accident, which are 14.9 per cent of the total deaths.

TABLE 139.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES AMONG COAL MINERS (OCCUPIED ONLY), ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

Age.	Deaths caused by nontuberculous respiratory diseases.							
	Bronchitis.		Pneumonia.		Other.		Total.	
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
15 to 24 years	7	0.3	170	7.3	22	0.9	199	8.5
25 to 34 years	33	1.3	270	10.7	32	1.3	335	13.3
35 to 44 years	79	3.0	309	11.7	63	2.4	451	17.1
45 to 54 years	246	7.5	368	11.2	125	3.8	739	22.4
55 to 64 years	596	15.4	322	8.3	174	4.5	1,092	28.2
65 years and over	839	20.0	175	4.2	157	3.7	1,171	27.9
Total, 15 years and over	1,800	9.5	1,614	8.6	573	3.0	3,987	21.1

According to Tables 138 and 139 the average proportion of deaths from pulmonary tuberculosis in the mortality of coal miners of England and Wales (occupied only) is 9.8 per cent, and the combined mortality from nontuberculous respiratory diseases is 21.1 per cent, chiefly attributable to bronchitis (9.5 per cent) and pneumonia (8.6 per cent). These proportions are extremely suggestive in that it is shown that the actual mortality from each of the three principal diseases, i. e., pulmonary tuberculosis, bronchitis, and pneumonia, is almost the same. In the United States this is true for pulmonary tuberculosis and pneumonia but not for bronchitis. Nor does this conclusion hold true, as subsequently shown, for some of the more important mining districts, which emphasizes the conclusion that the general mortality of coal miners from all forms of respiratory diseases is materially modified by special local conditions.

TABLE 140—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG COAL MINERS (OCCUPIED AND RETIRED), ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

Age at death.	Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent of deaths from all causes.
15 to 24 years	2,349	436	18.6
25 to 34 years	2,597	489	18.8
35 to 44 years	2,768	379	13.7
45 to 54 years	3,443	344	10.0
55 to 64 years	4,320	232	5.4
65 years and over	6,128	70	1.1
Total, 15 years and over	[1] 21,605	1,950	9.0

[1] Including 2,876 deaths from accident, which are 13.3 per cent of the total deaths.

TABLE 141.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES AMONG COAL MINERS (OCCUPIED AND RETIRED), ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

Age at death.	Deaths caused by nontuberculous respiratory diseases.							
	Bronchitis.		Pneumonia.		Other.		Total.	
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
15 to 24 years	7	0.3	172	7.3	22	0.9	201	8.6
25 to 34 years	33	1.3	275	10.6	36	1.4	344	13.2
35 to 44 years	80	2.9	316	11.4	66	2.4	462	16.7
45 to 54 years	254	7.4	377	10.9	130	3.8	761	22.1
55 to 64 years	666	15.4	342	7.9	188	4.4	1,196	27.7
65 years and over	1,201	19.6	245	4.0	200	3.3	1,646	26.9
Total, 15 years and over	2,241	10.4	1,727	8.0	642	3.0	4,610	21.3

Tables 140 and 141 furnish an answer to the question frequently raised as to how far the recorded mortality of coal miners is modified by the factor of occupational elimination, in that it is well known, of course, that a fair proportion of coal miners discontinue the employment on the first signs of lung injury and seek employment mostly outdoors in more healthy occupations. This conclusion, it is true, has been opposed by Wainwright and Nichols in their observations on pulmonary anthracosis, but no evidence has been forthcoming that in a general way the conclusion is unsound that a considerable proportion of men in nondusty trades have not been previously employed in the mining industry. The most recent English statistics have, therefore, been made to include the occupied and retired, or in other words, the men previously employed in coal mining and now retired from the occupation. This, of course, does not bring out the full force of the preceding observations, in that men actively engaged in other pursuits, though formerly coal miners, would be enumerated under the occupation followed irrespective of the length of trade life. The number of deaths from all causes in the preceding table is increased to 21,605, over 18,855 for occupied coal miners only. The increase in the main naturally concerns only ages 55 and over. The proportionate mortality from pulmonary tuberculosis is modified from 9.8 per cent for the occupied only to 9 per cent for the occupied and retired, but in contrast the mortality from bronchitis is increased from 9.5 per cent for the occupied only to 10.4 per cent for the occupied and retired. In a general way the inclusion of the retired may, however, be said not to affect materially general conclusions based upon the data for the occupied only, except in so far as the most advanced age groups are concerned.

MORTALITY OF MINERS IN THE NORTHUMBERLAND COAL FIELD.

For consideration in detail of the mortality from pulmonary tuberculosis and nontuberculous respiratory diseases among coal miners in the principal mining districts, the data for the Durham and Northumberland districts are given in the two tables following:

TABLE 142.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG COAL MINERS (OCCUPIED ONLY) IN THE DURHAM AND NORTHUMBERLAND DISTRICT, 1900 TO 1902, BY AGE GROUPS.

Age at death.	Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent of deaths from all causes.
15 to 24 years	493	145	29.4
25 to 34 years	463	112	24.2
35 to 44 years	490	73	14.9
45 to 54 years	680	65	9.6
55 to 64 years	838	43	5.1
65 years and over	1,090	12	1.1
Total, 15 years and over	[1] 4,054	450	11.1

[1] Including 518 deaths from accident, which are 12.8 per cent of the total deaths.

TABLE 143.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES AMONG COAL MINERS (OCCUPIED ONLY) IN THE DURHAM AND NORTHUMBERLAND DISTRICT, 1900 TO 1902, BY AGE GROUPS.

Age at death.	Deaths caused by nontuberculous respiratory diseases.							
	Bronchitis.		Pneumonia.		Other.		Total.	
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
15 to 24 years	4	0.8	15	3.0	7	1.4	26	5.3
25 to 34 years	5	1.1	25	5.4	4	0.9	34	7.3
35 to 44 years	11	2.2	35	7.1	15	3.1	61	12.4
45 to 54 years	23	3.4	67	9.9	19	2.8	109	16.0
55 to 64 years	81	9.7	50	6.0	41	4.9	172	20.5
65 years and over	132	12.1	36	3.3	37	3.4	205	18.8
Total, 15 years and over	256	6.3	228	5.6	123	3.0	607	15.0

The proportionate mortality from pulmonary tuberculosis in this important coal field is 11.1 per cent, in comparison with 9.8 for all occupied coal miners in England and Wales. The mortality from nontuberculous respiratory diseases, however, is 15 per cent, against a general average of 21.1 per cent for England and Wales. The proportion of accidents is slightly below the normal, but the most marked difference is in the distinctly smaller proportion of deaths from bronchitis and pneumonia.

MORTALITY OF MINERS IN THE LANCASHIRE DISTRICT.

The corresponding data for coal miners in the Lancashire district are given in Tables 144 and 145.

TABLE 144.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG COAL MINERS (OCCUPIED ONLY) IN THE LANCASHIRE DISTRICT, 1900 TO 1902, BY AGE GROUPS.

Age at death.	Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent of deaths from all causes.
15 to 24 years	351	52	14.8
25 to 34 years	424	57	13.4
35 to 44 years	454	63	13.9
45 to 54 years	575	58	10.1
55 to 64 years	570	33	5.8
65 years and over	375	6	1.6
Total, 15 years and over	[1] 2,749	269	9.8

[1] Including 395 deaths from accident, which are 14.4 per cent of the total deaths.

TABLE 145.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES AMONG COAL MINERS (OCCUPIED ONLY) IN THE LANCASHIRE DISTRICT, 1900 TO 1902, BY AGE GROUPS.

Age at death.	Deaths caused by nontuberculous respiratory diseases.							
	Bronchitis.		Pneumonia.		Other.		Total.	
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
15 to 24 years	2	0.6	40	11.4	3	0.9	45	12.8
25 to 34 years	11	2.6	71	16.7	6	1.4	88	20.8
35 to 44 years	23	5.1	78	17.2	7	1.5	108	23.8
45 to 54 years	64	11.1	93	16.2	22	3.8	179	31.1
55 to 64 years	100	17.5	69	12.1	18	3.2	187	32.8
65 years and over	96	25.6	19	5.1	8	2.1	123	32.8
Total, 15 years and over	296	10.8	370	13.5	64	2.3	730	26.6

The proportion of deaths from pulmonary tuberculosis is 9.8 per cent, the normal for all occupied coal miners in England and Wales, but the mortality from respiratory diseases is much higher and particularly so from bronchitis and pneumonia. In contrast to an average of only 15 per cent of deaths from this group of diseases in the mortality from all causes among the coal miners of Durham and Northumberland, the corresponding proportion in the mortality of the coal miners of Lancashire is 26.6 per cent. Even more interesting is the comparison in detail for bronchitis and pneumonia. The proportionate mortality from bronchitis is 6.3 per cent for Durham and Northumberland, against 10.8 per cent for Lancashire, while from pneumonia the corresponding proportions are 5.6 per cent and 13.5 per cent, respectively. How far these marked differences are attributable to variations in local mining conditions can not be stated at the present time. The proportions, however, are also affected by important differences in climatic conditions, atmospheric pollution, housing, habits, class of labor, etc.[1] Such conditions, however, can not explain the remarkably lower proportion of deaths from pulmonary tuberculosis at the younger ages in the Lancashire mining district. At ages 15 to 24 the proportion of pulmonary tuberculosis in Durham and Northumberland is 29.4 per cent of the mortality from all causes against 14.8 per cent in Lancashire, or just about one-half. At ages 25 to 34 the corresponding proportions are 24.2 per cent for Durham and Northumberland and 13.4 per cent for Lancashire. Extending the analysis to bronchitis, it is shown that the proportions are relatively low for every divisional period of life, except 15 to 24 years, for Durham and Northumberland in comparison with Lancashire, and at some ages, particularly 45 to 54, when the effect of occupation is most pronounced, the proportion of deaths from bronchitis in Durham and Northumberland is only 3.4 per cent of the deaths from all causes at this period of life against 11.1 per cent for Lancashire. An analysis of the mortality from pneumonia by divisional periods of life yields much the same result. The proportionate mortality from this disease is decidedly less at every age group in the Durham and Northumberland mining district than in the corresponding district of Lancashire. It may be said in this connection that the proportionate mortality from accidents is nearly the same.

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[1] It would make a most interesting and valuable contribution to the scientific study of this question if the comparative climatological factors of the American and British coal fields were subjected to a critical analysis. All of the essential data should be available through the annual and monthly meteorological reports of the two countries, but especially as regards England, a fairly sufficient amount of consolidated climatological information is available through the report of the Royal Medical and Chirurgical Society of London, issued under the title, "The Climates and Baths of Great Britain," in two volumes, London, 1895 and 1902. This report includes some exceedingly valuable maps and charts, which it should not be difficult to correlate to the corresponding maps descriptive of the principal coal fields of the United Kingdom.

MORTALITY OF MINERS IN THE WEST RIDING DISTRICT.

Similar data for coal miners in the West Riding district are given in Tables 146 and 147, as follows:

TABLE 146.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG COAL MINERS (OCCUPIED ONLY) IN THE WEST RIDING DISTRICT, 1900 TO 1902, BY AGE GROUPS.

Age at death.	Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent of deaths from all causes.
15 to 24 years	280	49	17.5
25 to 34 years	319	60	18.8
35 to 44 years	387	53	13.7
45 to 54 years	430	62	14.4
55 to 64 years	487	27	5.5
65 years and over	488	4	.8
Total, 15 years and over	[1] 2,391	255	10.7

[1] Including 329 deaths from accident, which are 13.8 per cent of the total deaths.

TABLE 147.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES AMONG COAL MINERS (OCCUPIED ONLY) IN THE WEST RIDING DISTRICT, 1900 TO 1902, BY AGE GROUPS.

Age at death.	Deaths caused by nontuberculous respiratory diseases.							
	Bronchitis.		Pneumonia.		Other.		Total.	
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
15 to 24 years			17	6.1			17	6.1
25 to 34 years	3	0.9	39	12.2			42	13.2
35 to 44 years	14	3.6	39	10.1	11	2.8	64	16.5
45 to 54 years	32	7.4	42	9.8	16	3.7	90	20.9
55 to 64 years	69	14.2	35	7.2	14	2.9	118	24.2
65 years and over	103	21.1	23	4.7	23	4.7	149	30.5
Total, 15 years and over	221	9.2	195	8.2	64	2.7	480	20.1

In the West Riding district the proportionate mortality from pulmonary tuberculosis is 10.7 per cent, which compares with 9.8 per cent for all coal miners in England and Wales, 11.1 per cent for all in Durham and Northumberland, and 9.8 per cent for all in Lancashire. The proportions are relatively low at the younger ages compared with the corresponding mortality for the mining district of Durham and Northumberland, and relatively high compared with that for Lancashire. The exceptionally high mortality from pulmonary tuberculosis in Durham and Northumberland remains, therefore, in marked contrast with the lower mortality in other important mining districts, while by way of contrast the mortality from nontuberculous lung diseases is distinctly low in the district of Durham and

Northumberland, while relatively high in other sections. In West Riding, however, the combined mortality from nontuberculous respiratory diseases is 20.1 per cent, compared with 26.6 per cent for Lancashire and 15 per cent for Durham and Northumberland. This excess for Lancashire is chiefly attributable to a relatively high mortality from bronchitis and pneumonia. The mortality from accidents in the West Riding district is 13.8 per cent, compared with 14.9 per cent for all coal miners in England and Wales. This factor, therefore, can not be considered of importance in materially altering the relative proportions of deaths from specified diseases. Throughout it may be said that the bronchitis and pneumonia mortality of the West Riding district conforms to the normal for the United Kingdom. But it is suggestive that the mortality from bronchitis at ages 65 and over should be 21.1 per cent in West Riding against 12.1 per cent in Durham and Northumberland and 25.6 per cent in Lancashire. A correct interpretation of these differences is obviously impossible without a thorough knowledge of many important local contributory conditions.[1]

MORTALITY OF MINERS IN THE DERBYSHIRE AND NOTTINGHAMSHIRE DISTRICT.

Corresponding data for coal miners in the Derbyshire and Nottinghamshire district are given in Tables 148 and 149, which follow:

TABLE 148.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG COAL MINERS (OCCUPIED ONLY) IN THE DERBYSHIRE AND NOTTINGHAMSHIRE DISTRICT, 1900 TO 1902, BY AGE GROUPS.

Age at death.	Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent of deaths from all causes.
15 to 24 years	209	47	22.5
25 to 34 years	176	34	19.3
35 to 44 years	216	28	13.0
45 to 54 years	265	28	10.6
55 to 64 years	341	16	4.7
65 years and over	465	7	1.5
Total, 15 years and over	[a] 1,672	160	9.6

[a] Including 202 deaths from accident, which are 12.1 per cent of the total deaths.

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[1] There are no available precise observations on variations in underground temperatures in coal mines. It is quite possible that such variations in the different coal areas may have an important bearing upon the relative frequency from nontuberculous respiratory diseases. An important contribution to this aspect of the problem is an address on "The Influence of Underground Temperatures upon the Labor Capacity of Miners," by Prof. John Cadman, of the University of Birmingham.

TABLE 149.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES AMONG COAL MINERS (OCCUPIED ONLY) IN THE DERBYSHIRE AND NOTTINGHAMSHIRE DISTRICT, 1900 TO 1902, BY AGE GROUPS.

Age at death.	Deaths from nontuberculous respiratory diseases.							
	Bronchitis.		Pneumonia.		Other.		Total.	
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
15 to 24 years	......	......	16	7.7	1	0.5	17	8.1
25 to 34 years	3	1.7	9	5.1	3	1.7	15	8.5
35 to 44 years	6	2.8	26	12.0	2	.9	34	15.7
45 to 54 years	10	3.8	21	7.9	8	3.0	39	14.7
55 to 64 years	43	12.6	23	6.7	15	4.4	81	23.8
65 years and over	108	23.2	19	4.1	19	4.1	146	31.4
Total, 15 years and over	170	10.2	114	6.8	48	2.9	332	19.9

The proportionate mortality from pulmonary tuberculosis in the Derbyshire and Nottinghamshire district is 9.6 per cent, which compares with 9.8 per cent for all coal miners in England and Wales. The proportionate mortality from nontuberculous respiratory diseases considered in the aggregate is 19.9 per cent of deaths from all causes against 21.1 per cent for all coal miners in England and Wales; 15.0 per cent for Durham and Northumberland; 26.6 per cent for Lancashire; and 20.1 per cent for West Riding. The mortality from the different forms of tuberculous and respiratory diseases conforms, in the main, to the general experience and indicates no very important variations, excepting that the mortality from bronchitis and pneumonia is relatively low at the younger ages.

MORTALITY OF MINERS IN THE STAFFORDSHIRE DISTRICT.

The data for coal miners in the Staffordshire district are given in Tables 150 and 151, as follows:

TABLE 150.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG COAL MINERS (OCCUPIED ONLY) IN THE STAFFORDSHIRE DISTRICT, 1900 TO 1902, BY AGE GROUPS.

Age at death.	Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent of deaths from all causes.
15 to 24 years	166	21	12.7
25 to 34 years	174	27	15.5
35 to 44 years	195	28	14.4
45 to 54 years	327	28	8.6
55 to 64 years	374	10	2.7
65 years and over	520	5	1.0
Total, 15 years and over	[1] 1,756	119	6.8

[1] Including 233 deaths from accident, which are 13.3 per cent of the total deaths.

TABLE 151.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES AMONG COAL MINERS (OCCUPIED ONLY) IN THE STAFFORDSHIRE DISTRICT, 1900 TO 1902, BY AGE GROUPS.

Age at death.	Deaths caused by nontuberculous respiratory diseases.							
	Bronchitis.		Pneumonia.		Other.		Total.	
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
15 to 24 years			12	7.2	1	0.6	13	7.8
25 to 34 years	1	0.6	12	6.9	5	2.9	18	10.3
35 to 44 years	4	2.1	14	7.2	5	2.6	23	11.8
45 to 54 years	38	11.6	29	8.9	18	5.5	85	26.0
55 to 64 years	75	20.1	34	9.1	16	4.3	125	33.4
65 years and over	134	25.8	16	3.1	18	3.5	168	32.3
Total, 15 years and over	252	14.4	117	6.7	63	3.6	432	24.6

The proportionate mortality from pulmonary tuberculosis in the Staffordshire district is only 6.8 per cent, in marked contrast to an average proportion of 9.8 per cent for all coal fields of England and Wales, and a maximum proportion of 11.1 per cent for the Durham and Northumberland district. The combined mortality from nontuberculous respiratory diseases, however, is distinctly above the average, or 24.6 per cent, against 21.1 per cent for all coal fields, and a minimum of 15 per cent for the Durham and Northumberland district. The mortality from bronchitis is exceptionally low at the younger ages, but for all ages combined the proportion of deaths from this disease is relatively high, or 14.4 per cent, against 9.5 per cent for all coal fields, 6.3 per cent for Durham and Northumberland, 10.8 per cent for Lancashire, 9.2 per cent for West Riding, and 10.2 per cent for Derbyshire and Nottinghamshire. This excessive incidence of bronchitis is particularly suggestive at the older ages, and, for illustration, at ages 65 and over, the proportion of deaths from bronchitis in the mortality from all causes of coal miners in the Staffordshire district is 25.8 per cent against 20 per cent for all coal miners, 12.1 per cent for Durham and Northumberland, 25.6 per cent for Lancashire, 21.1 per cent for West Riding, and 23.2 per cent for Derbyshire and Nottinghamshire. The proportionate mortality from accidents in the Staffordshire coal fields is 13.3 per cent, or not much at variance with the normal of 14.9 per cent for all coal fields.

MORTALITY OF MINERS IN THE MONMOUTHSHIRE AND SOUTH WALES DISTRICT.

The data for coal miners in the Monmouthshire and South Wales district are given in Tables 152 and 153, as follows:

TABLE 152.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG COAL MINERS (OCCUPIED ONLY) IN THE MONMOUTHSHIRE AND SOUTH WALES DISTRICT, 1900 TO 1902, BY AGE GROUPS.

Age at death.	Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent of deaths from all causes.
15 to 24 years	663	92	13.9
25 to 34 years	731	120	16.4
35 to 44 years	698	94	13.5
45 to 54 years	735	66	9.0
55 to 64 years	885	52	5.9
65 years and over	731	10	1.4
Total, 15 years and over	[1] 4,443	434	9.8

[1] Including 895 deaths from accident, which are 20.1 per cent of the total deaths.

TABLE 153.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES AMONG COAL MINERS (OCCUPIED ONLY) IN THE MONMOUTHSHIRE AND SOUTH WALES DISTRICT, 1900 TO 1902, BY AGE GROUPS.

Age at death.	Deaths caused from nontuberculous respiratory diseases.							
	Bronchitis.		Pneumonia.		Other.		Total.	
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
15 to 24 years	1	0.2	56	8.4	6	0.9	63	9.5
25 to 34 years	9	1.2	92	12.6	11	1.5	112	15.3
35 to 44 years	16	2.3	94	13.5	20	2.9	130	18.6
45 to 54 years	61	8.3	89	12.1	30	4.1	180	24.5
55 to 64 years	181	20.5	83	9.4	49	5.5	313	35.4
65 years and over	167	22.8	42	5.7	29	4.0	238	32.6
Total, 15 years and over	435	9.8	456	10.3	145	3.3	1,036	23.3

The proportionate mortality from pulmonary tuberculosis in Monmouthshire and South Wales coal fields is the same as for all coal fields combined, or 9.8 per cent. The aggregate mortality from all forms of nontuberculous respiratory diseases is 23.3 per cent for Monmouthshire and South Wales, against 21.1 per cent for all coal mines in England and Wales and a minimum of 15 per cent for the Durham and Northumberland district. The proportionate mortality from pulmonary tuberculosis by divisional periods of life indicates nothing abnormal; in fact, the indications are rather suggestive of a relatively low rate of incidence in comparison with other mining districts. For illustration, at ages 15 to 24 the proportion of deaths in Monmouthshire and South Wales is 13.9 per cent, against 29.4 per cent for Durham and Northumberland; at ages 25 to 34 the corresponding proportions are 16.4 per cent for Monmouthshire and South Wales, against 24.2 per cent for Durham and Northumberland; but at ages 35 and over the proportions tend toward conformity. It is, however, extremely suggestive that, comparing the two coal fields, the mortality from nontuberculous respiratory diseases should be so decidedly at variance. The proportion of deaths from bronchitis, for illustration, in Durham and Northumberland is 6.3 per cent, against 9.8 per cent for Monmouthshire and South Wales, and for pneumonia the corresponding proportions are 5.6 per cent and 10.3 per cent, respectively. To a limited extent these statistics are affected, of course, by the higher proportion of accidental deaths in the Monmouthshire and South Wales coal-mining district, as 20.1 per cent of deaths from all causes are from accidents, against 12.8 per cent for Durham and Northumberland. While the two mining districts have approximately the same mining population, however, and the same number of deaths from pulmonary tuberculosis, there are only 256 deaths from bronchitis in Durham and Northumberland, against 435 deaths in Monmouthshire and South Wales; and 228 deaths from pneumonia in Durham and Northumberland, against 456 deaths in Monmouthshire and South Wales. The relative mortality rates, therefore, per thousand exposed to risk would confirm the general conclusions based upon the proportional data, regardless of the important differences in the relative frequency of mine accidents.

EFFECT OF VARIATIONS IN LOCAL CONDITIONS ON THE MORTALITY FROM RESPIRATORY DISEASES.

This rather extended analysis is far from sufficient for the purpose of emphasizing concisely and conclusively the local variations in the proportionate mortality from pulmonary tuberculosis and nontuberculous respiratory diseases in the different mining districts of England and Wales. It is a safe inference, however, that corresponding variations would be disclosed by a similar analysis of the mortality data for the different coal fields of the United States, which, however, unfortunately at the present time are not available. The differences are unquestionably in a measure attributable to local climatic variations, fogs, smoke, etc., which influence the death rates from nontuberculous respiratory diseases, aside from equally if not more important differences in habits, housing, and labor conditions. How far the medical terminology is entirely trustworthy is also an open question. It is quite possible that death certification is more accurate and complete in England and Wales than in the United States, and that the higher mortality from bronchitis and pneumonia is a true difference on account of accuracy in diagnosis, based upon a careful consideration of all the clinical symptoms of the diseases. The differential diagnosis of true pulmonary tuberculosis involves serious difficulties which, on the part of the superficial practitioner, may frequently lead to a death being assigned to pulmonary tuberculosis when as a matter of fact the disease was not true tuberculosis but a true pneumoconiosis or anthracosis, as the case may be. It is, therefore, of much importance that the subject should receive more extended critical and qualified scientific consideration, so that sound conclusions may be available in place of more or less misleading and superficial generalities.

RELATIVE FREQUENCY OF ANTHRACOSIS.

The problem under consideration is much more complex than in the case of occupations where the accident factor is of relatively lesser importance. When, however, reasonable allowance is made for the effects of accidents upon the mortality of coal miners from pulmonary tuberculosis, it is safe to assume that in coal mining there is a lesser inherent liability to this disease than in metal mining in consequence of the special mechanical and chemical properties of coal dust, aside, of course, from certain well-recognized changes, such as materially improved methods of ventilation, better air conditions, lesser air pollution by high explosives, etc. Shufflebotham, in his Milroy Lectures on the "Hygienic aspect of the coal-mining industry in the United Kingdom," has stated that at the present time "in Great Britain fibrosis of the lungs among miners can be said to be practically nonexistent, and its disappearance can be wholly attributed to the enforced improvements in the ventilation in mines, to improvements in illumination, and to shorter working hours." He remarks that the evidence given before the departmental committee on industrial diseases was practically unanimous on this point. No corresponding investigations have been made in this country regarding the occurrence of true fibroid phthisis or nontuberculous lung disease among coal miners. Anthracosis, or infiltration of the lung with coal dust, is, of course, extremely common; in fact, universal. Investigations made in this country are quite conclusive that more or less health-injurious consequences must in course of time result from an extensive coal-dust infiltration. As regards pulmonary tuberculosis the experience in this country is confirmed by the investigations of Shufflebotham, who remarks, with special reference to Great Britain, that—

> Tuberculosis of the lungs is not so commonly found among coal miners as among many other occupations, and the statistics of the registrar general with regard to mortality from this cause show that while the mortality figure for all occupied males in England and Wales is 175, that for the coal miner is only 85; metalliferous miners, however, are not so fortunate in this respect, the figure for the Cornish tin miner being 838 (the highest on the list of all occupations); the copper miner, 501; and the lead miner, 344. With regard to other diseases of the respiratory system, while the mortality figure for all occupied males is 78, that for the coal miner is 140. The copper miner heads the list with 665, the tin miner coming second,

with a mortality figure of 187; the potter and the Sheffield grinder—frequent victims of this disease—are represented by mortality figures of 361 and 173, respectively.

Shufflebotham, in the lecture referred to, makes brief mention of American investigations by Wainwright and Nichols, whose experience was drawn from an extensive area of observations, and who conclude that "miners' asthma" is clinically chronic bronchitis and emphysema and that it is associated with epithelial irritation, thickening of the connective tissue and consequent loss of elasticity. "Miners' asthma" is a term in rather common use in the coal regions, but the general inference is that there are no serious complications with pulmonary tuberculosis, nor is the actual mortality from this disease as high as would naturally be expected. Collis, in his Milroy Lectures on "Industrial pneumoconiosis," observes, with reference to true dust asthma, that it is always associated with an excessive incidence of bronchitis; and he briefly presents the distinctive features of this form of asthma as follows: "(i) Occurrence of asthmatic attacks during exposure to dust and the cessation of attacks on leaving the dusty atmosphere, (ii) immobility of the diaphragm, and (iii) overaction of the superior intercostal and extraordinary muscles of respiration." With special reference to coal miners he remarks that—

> Fifty years ago asthma was common among coal miners. "Then in every little mining village," writes the secretary of a miners' association, "there was a contingent of old miners past work on account of difficulty of breathing, a stage usually reached between 40 and 50 years of age"; and this statement is borne out by Greenhow, who tells of the ravages wrought in his day among coal miners in South Staffordshire by asthma. "Some miners retain their health till an advanced period of life, but the greater number suffer, more or less, from asthmatical symptoms before attaining the age of 50, and many break down and are disabled at 40 to 50 years of age, * * * a miner is usually an old man at 50, and few men * * * are found at work beyond that age." The same observer also mentions the disease as prevalent in the South Wales coal field, and while attributing it to bad ventilation in the mines, states that the miners blamed the fumes from explosives. He contrasts the condition with that seen among lead miners and tin miners, as one with emphysema more frequent, with less pneumonia, developing later in life, and, while associated with chronic bronchitis, not associated at an early period of life with slight dyspnœa.

Collis also refers to investigations by Wainwright and Nichols, published in the Journal of Medical Sciences for 1905 under the title "The relation between anthracosis and pulmonary tuberculosis," stating, in part, that at Scranton during 1894–1904 asthma accounted for 7 per cent of all deaths among coal miners as compared with 1.6 per cent among all occupied males; and these observers further state that the condition as seen among the miners is one of chronic bronchitis and emphysema. After carefully considering all the medical aspects of the disease, Collis concludes that the exact terminology of the disease remains somewhat doubtful, but that though formerly quite common, it is now extremely rare in its classical form, at least in the coal mines of the United Kingdom.[1] Shufflebotham concludes his observations on coal dust with the following interesting and important statement, also including observations by Wainwright and Nichols, based upon American experience:

> It has been asserted by many authorities that coal dust has germicidal properties, and in favor of this view we have the experience of colliery surgeons who record that extensive wounds full of coal dust heal rapidly, and even lacerated wounds sustained through injuries in coal mines can be stitched up without hesitation; veterinary surgeons have similar experience in the treatment of pit ponies. As a result of their experiments Wainwright and Nichols dismissed the theory that coal dust possesses any germicidal property; they believe that coal dust in the lungs does exert a real protective influence against the tubercle bacilli, but that the reduced mortality from tuberculosis is not due to any antiseptic property of the coal dust but to its stimulating effect on the lung tissue and increased growth of connective tissue. Among other experiments they kept guinea.pigs for two months in an atmosphere of coal dust, and afterwards a pure culture of tubercle bacilli was injected. Animals were treated similarly who had not been subjected to the coal dust. They found that in the latter cases tubercle was found in the lung on post-mortem examination, but that in the former case no tubercles could be detected. Nichols advances the theory that the protective influence of the coal dust is due to the action of the soluble calcium salts which form a large proportion of the ash of the coal dust.

COMPARATIVE MORTALITY IN COAL MINING AND AGRICULTURE.

As explained in the general introduction, the proportionate mortality is more useful and conclusive in connection with inquiries into the medical aspects of industrial hygiene than the use of mortality rates per thousand of those exposed to risk. Whenever available, however, such rates can be utilized to good advantage, and in Table 154 the general mortality of the coal miners of England and Wales, by divisional periods of life, is compared with the mortality of occupied males in agricultural districts. The comparison also includes the data in detail for the six mining districts of the United Kingdom.

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[1] For a more recent discussion of the relation of coal dust to phthisis, see The Hospital, London, June 17, 1916, p. 252.

TABLE 154.—COMPARATIVE MORTALITY (RATES PER 1,000) FROM ALL CAUSES AMONG COAL MINERS (OCCUPIED ONLY) AND OCCUPIED MALES IN AGRICULTURAL DISTRICTS, ENGLAND AND WALES, 1900 TO 1902.

Age at death.	Occupied males (agricultural districts).	Coal miners (all districts).	Durham and Northumberland.	Lancashire.	West Riding.	Derbyshire and Nottinghamshire.	Staffordshire.	Monmouthshire and South Wales.
15 to 19 years..........	1.95	3.20	3.14	3.65	2.85	2.56	2.49	4.03
20 to 24 years..........	4.21	4.47	4.88	4.86	3.40	3.79	4.00	5.01
25 to 34 years..........	5.16	4.93	4.54	6.01	4.27	3.33	4.16	5.78
35 to 44 years..........	7.17	7.65	6.76	9.03	7.48	5.97	6.65	8.91
45 to 54 years..........	11.73	14.67	13.79	17.44	13.01	11.25	16.07	15.94
55 to 64 years..........	22.53	35.98	31.63	42.41	33.97	31.25	38.00	39.84
65 years and over.....	85.08	139.82	155.40	136.61	142.19	149.04	163.21	105.30

The table clearly reflects the relatively favorable mortality of coal miners, but some important exceptions to this conclusion are brought out by the comparison, particularly for certain mining districts and the more advanced age periods. The rates are highest at ages 25 to 64 in the Lancashire district, and at ages 65 and over in the mining district of Staffordshire. At the younger ages, that is, under 25, the rates are highest in the mining district of Monmouthshire and South Wales.

A similar comparison of the mortality from pulmonary tuberculosis (phthisis) is shown in Table 155.

TABLE 155.—COMPARATIVE MORTALITY (RATES PER 1,000) FROM PHTHISIS OF COAL MINERS (OCCUPIED ONLY) AND OCCUPIED MALES IN AGRICULTURAL DISTRICTS, ENGLAND AND WALES, 1900 TO 1902.

Age at death.	Occupied males (agricultural districts).	Coal miners (all districts).	Durham and Northumberland.	Lancashire.	West Riding.	Derbyshire and Nottinghamshire.	Staffordshire.	Monmouthshire and South Wales.
15 to 19 years..........	0.36	0.41	0.73	0.36	0.39	0.32	0.15	0.34
20 to 24 years..........	1.09	1.01	1.65	.89	.70	1.13	.68	.90
25 to 34 years..........	1.10	.91	1.10	.81	.80	.64	.65	.95
35 to 44 years..........	1.02	1.05	1.01	1.25	1.02	.77	.95	1.20
45 to 54 years..........	1.16	1.47	1.32	1.76	1.88	1.19	1.38	1.43
55 to 64 years..........	.88	1.84	1.62	2.45	1.88	1.47	1.02	2.34
65 years and over.....	.81	1.63	1.71	2.17	1.16	2.24	1.57	1.44

The table emphasizes the wide variations in the specific death rates of pulmonary tuberculosis in the different mining districts and the relatively low rates prevailing in all districts when comparison is made with the corresponding mortality of occupied males in agricultural districts. It must be considered in this connection, however, that the social and economic status of agricultural labor in England and Wales is distinctly below the average for the United States.

On account of the exceptional importance of the nontuberculous respiratory diseases in the case of coal miners, Table 156 shows the rates of mortality from bronchitis and pneumonia, in a manner uniform with the preceding tables for all causes and for pulmonary tuberculosis.

TABLE 156.—COMPARATIVE MORTALITY (RATES PER 1,000) FROM BRONCHITIS AND PNEUMONIA OF COAL MINERS (OCCUPIED ONLY) AND OCCUPIED MALES IN AGRICULTURAL DISTRICTS, ENGLAND AND WALES, 1900 TO 1902.

Age at death.	Occupied males (agricultural districts).	Coal miners (all districts).	Durham and Northumberland.	Lancashire.	West Riding.	Derbyshire and Nottinghamshire.	Staffordshire.	Monmouthshire and South Wales.
BRONCHITIS.								
15 to 19 years	0.0083	0.0032	0.0154	....	....	....	....	....
20 to 24 years	....	.0199	.0505	0.0469	....	....	....	0.0138
25 to 34 years	.0261	.0646	.0490	.0156	0.0402	0.0567	0.0239	.0711
35 to 44 years	.0713	.2284	.1517	.4572	.2706	.1660	.1363	.2048
45 to 54 years	.2179	1.0951	.4663	1.9410	.9671	.4244	1.8680	1.3230
55 to 64 years	.9593	5.5466	3.0570	7.4400	4.8120	3.9410	7.6200	8.1470
65 years and over	.8431	27.9639	18.8600	34.9700	30.0100	34.6000	42.1000	24.0606
PNEUMONIA.								
15 to 19 years	.0794	.2339	.0929	.4309	.1317	.2913	.1132	.3323
20 to 24 years	.0201	.3250	.1516	.5404	.2492	.1881	.3598	.4429
25 to 34 years	.2349	.5285	.2452	1.0058	.5225	.1701	.2870	.7270
35 to 44 years	.5510	.8932	.4828	1.5500	.7540	.7191	.4771	1.2040
45 to 54 years	.8084	1.6382	1.3580	2.8210	1.2704	.8912	1.4250	1.9300
55 to 64 years	1.1620	2.9966	1.8770	5.1300	2.4410	2.1080	3.4500	3.7360
65 years and over	2.7620	5.8328	5.1300	6.9200	6.7000	6.0900	5.0200	6.0500

These tables will be found exceptionally useful in the furtherance of an effort to ascertain in a more conclusive manner the true incidence of pulmonary tuberculosis and nontuberculous respiratory diseases among coal miners, with a due regard to the geographical distribution of the mining industry. It sustains the earlier conclusion that the relative infrequency of pulmonary diseases among coal miners is more apparent than real, when consideration is given to the excess in the mortality from nontuberculous respiratory diseases among coal miners, in comparison with other industries or labor employed in agriculture. The entire question of anthracosis, or coal miners' phthisis, has been recently reviewed by Sir Thomas Oliver, in Kober and Hanson's Diseases of Occupation and Vocational Hygiene. Sir Thomas Oliver explains that "from an historical point of view the opening out of the South Wales coal fields is a modern development compared with those of Northumberland, but owing to the smokeless character of the coal and its suitability for steamship purposes, the industry received an impetus half a century ago which has not yet begun to decline." He recalls that, "When Sir John Simon wrote upon the subject nearly 50 years ago he was of the opinion that there was a larger amount of bronchial and respiratory diseases among the Welsh miners than among the Northumberland, a circumstance which he attributed to the better ventilation of the mines in the North of England." These earlier observations are only to a limited extent confirmed by more recent experience, which does not indicate an excess of pneumonia or bronchitis in the coal fields of Monmouthshire and South Wales, as clearly brought out by the preceding series of tables.

ANTHRACOSIS AND PHTHISIS.

Unfortunately most of the prevailing views regarding anthracosis, or the so-called coal miners' phthisis, are not based upon a thorough and critical analysis of morbidity and mortality data. This conclusion applies to the very interesting observations of Wainwright and Nichols, first published in the American Journal of the Medical Sciences (1905) under the title, "The relation between anthracosis and pulmonary tuberculosis." The conclusions advanced rest in part upon a superficial analysis of the mortality statistics of the United States census for 1900 and a special analysis of the death certificates of the city of Scranton, Pa. The authors observe that miners' phthisis is an unfortunate term used in England, and undoubtedly a misnomer as far as the phthisical aspect of miners' lung diseases is concerned. Tuberculous lesions in miners are, of course, due to the tubercle bacillus, without which, in other words, true tuberculosis can not exist. The nontuberculous lung diseases among coal miners in particular are, therefore, of special importance; but there are reasons for believing that a clinical diagnosis is frequently quite superficial and fails to distinguish fairly between a case of true phthisis, or pulmonary tuberculosis, and a case of apparent phthisis, or anthracosis, which is, in its inception at least, a nontuberculous lung disease, manifesting itself in a chronic bronchitis, asthma, or pneumonia. By means of special methods of research Wainwright and Nichols ascertained that the foreign matter in the lungs of old miners, on the basis of autopsy findings, was about 33 per cent of the dried lung, whereas in normal subjects not especially exposed to dust the proportion is only from 1 to 3 per cent. In view of the thorough impregnation of the lung with coal dust, it is, therefore, difficult to accept the conclusion that such impregnation to the quantitative extent of one-third of the lung substances should not be injurious.

It is true, as pointed out by Wainwright and Nichols, that there are special advantages in mine work, and that in Pennsylvania in particular the mine employee frequently "has to walk several miles to the shaft through the fine air of high altitudes," and there is the additional advantage of a fairly satisfactory economic status. All of this, no doubt, must have some influence on the health of miners in general, and the relative frequency of pulmonary tuberculosis in particular. The authors, however, go too far when they maintain that it is not a fact that miners who have contracted tuberculosis frequently seek lighter work, and frequently on death they are registered in the second occupation, to which they do not belong, and that, therefore, the true death rate among miners is artificially reduced. To anyone thoroughly familiar with the conditions in the mining districts of the United States there can be no question of doubt that labor changes are quite common and that in a measure they are directly attributable to a desire to replace an apparently unhealthful employment underground, by an occupation with a lesser liability to diseases resulting from continuous and considerable coal-dust exposure. (On this point, see p. 381.)

The same authors hold that there is also no justification for the view that there is a process of natural selection in the case of miners, in accordance with which the physically superior type would seek employment, rather than the general average of boys and men not particularly concerned as regards the physical aptitude for the more or less arduous work underground. They hold that weaklings, even when admitted to the mining occupations, are not weeded out later, and that mine labor "is certainly not more laborious than that of the farm laborer, with whom they are nearly equal in point of tuberculosis mortality." This conclusion can not be accepted, for mine labor underground is continuous during 8, 9, or 10 hours, as the case may be, whereas farm labor is intermittent, and excessive physical strain is rather exceptional. In modern coal mining, practically on account of the extensive use of heavy mining machinery, the physical requirements are, in all probability, even greater than under the earlier conditions of mining by pick and hand. (See p. 319.)

The analysis of the Scranton vital statistics was not made with reference to age, so that the proportionate mortality figure of 3.37 per cent of deaths from pulmonary tuberculosis can hardly be considered conclusive when compared with the corresponding percentage for other occupied males of 9.97. The authors do not draw sufficient attention to the fact that the proportion of deaths from asthma in their own figures was 7.07 per cent for anthracite coal miners against 1.58 per cent for all other occupied males, and throughout their discussion they fail to emphasize the possible nonapplication of their conclusion to bituminous coal miners, with whom the conditions may vary fundamentally as regards the chemical and mechanical properties of the coal dust from the corresponding conditions in anthracite mining. After combining the proportionate mortality from all lung diseases, whether tuberculous or nontuberculous, the results show that of the deaths of anthracite mine workers 23.45 per cent were caused by this group of respiratory diseases against 27.86 per cent for all other occupied males. It is quite probable that the latter group includes a considerable proportion of men who formerly worked in mines, which in part would account for the higher proportionate mortality figure from pneumonia, or 13.85 per cent for all other occupied males at Scranton against 10.96 per cent for anthracite mine workers.

The vital statistics of the State of Pennsylvania, unfortunately, are not available by occupations, with a due regard to divisional periods of life. The city of Scranton consists so largely of men employed in coal mining, or formerly employed in that occupation, that it is of some significance that the proportionate mortality from tuberculous and respiratory diseases should be 23.6 per cent of the mortality from all causes against 22.2 per cent for the State of Pennsylvania.[1] Similar data for the city of Wilkes-Barre show a divergence from the Scranton data and indicate a lower proportion of deaths from pulmonary tuberculosis and pneumonia but a somewhat higher proportion of deaths from accidents. Excluding the deaths from accidents, it appears that in Scranton 26.4 per cent of all the deaths are caused by tuberculous or nontuberculous respiratory diseases against 23.1 per cent for the city of Wilkes-Barre and 23.9 per cent for the State of Pennsylvania. When, therefore, proper allowance is made for the factor of occupational elimination, the available data indicate that the alleged immunity of coal miners from pulmonary tuberculosis, while unquestionably true in a measure, is not as important as generally assumed on account of the relatively excessive mortality from nontuberculous respiratory diseases, of which no doubt a considerable proportion are deaths from anthracosis not complicated by a superinduced pulmonary tuberculosis or true phthisis. There is the utmost urgency in this matter that old and more or less general and frequently misleading

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[1] A more recent analysis of the mortality of the city of Scranton, with comparative data for Wilkes-Barre and the remainder of the State, for the period 1911 to 1915, is as follows:

Comparative mortality of Pennsylvania, 1911 to 1915.

[Rate per 100,000 population.]

Cause of death.	Scranton.	Wilkes-Barre.	Remainder of State.
Pulmonary tuberculosis	79.9	74.9	110.5
Other tuberculosis	16.6	19.4	16.4
Respiratory diseases	261.2	212.5	184.2
Violence	153.5	179.7	98.9

According to this table, which, of course, is for the general population and not exclusively for the mining population, the mortality from tuberculosis attributable to the two principal urban centers of the anthracite mining industry was considerably below the average for the remainder of the State; in contrast, the mortality from nontuberculous respiratory diseases was quite considerably in excess for both Scranton and Wilkes-Barre, aside from a much higher mortality than these two localities for violence. The proportion of population, ages 15 to 64 years, is practically the same, or about 65 per cent, in Scranton, Wilkes-Barre, and the remainder of the State; the proportion of population, ages 65 years and over, however, according to the census of 1910, was 2.8 per cent for Scranton, 2.9 per cent for Wilkes-Barre, against 4.3 per cent for the State as a whole.

data and observations should be disregarded and that the entire question should be subjected to a strictly scientific and critical analysis. Conclusions based upon fragmentary observations derived from the experience of physicians in coal-mining centers throughout the world can not be safely applied to modern coal-mining conditions in the United States. The relatively high mortality from asthma, bronchitis, and pneumonia among coal miners is certainly suggestive of more or less health-injurious conditions underground, probably directly related to dust exposure, which can not be explained on any other principle of correlation in disease.

MORTALITY OF AMERICAN COAL MINERS.

Table 157 shows the proportionate mortality of coal miners in the experience of the Prudential Insurance Co. of America for the period 1907 to 1914, including 3,658 deaths from all causes and 354 deaths from pulmonary tuberculosis, or 9.7 per cent. This is almost the exact proportion (9.8 per cent) ascertained by the analysis of the English mortality statistics for occupied miners only for an earlier period.

TABLE 157.—PROPORTIONATE MORTALITY OF COAL MINERS FROM PULMONARY TUBERCULOSIS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1907 TO 1914, BY AGE GROUPS.

Age at death.	Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent of deaths from all causes.
15 to 24 years	364	27	7.4
25 to 34 years	395	52	13.2
35 to 44 years	468	58	12.4
45 to 54 years	840	103	12.3
55 to 64 years	917	78	8.5
65 years and over	674	36	5.3
Total, 15 years and over	3,658	354	9.7

TABLE 158.—PROPORTIONATE MORTALITY OF COAL MINERS FROM NONTUBERCULOUS RESPIRATORY DISEASES, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1907 TO 1914, BY CAUSE OF DEATH.

Cause of death.	Deaths from nontuberculous respiratory diseases.	
	Number.	Per cent of deaths from all causes.
Asthma	137	3.7
Bronchitis	81	2.2
Pneumonia	397	10.9
Other nontuberculous respiratory diseases	124	3.4
Total	739	20.2
Accidents	885	24.2

The comparison of the Prudential and English experiences is exceptionally instructive. The combined mortality from nontuberculous respiratory diseases in the English experience was 21.1 per cent, against 20.2 per cent in the experience of the Prudential Co., but the details of the experience vary widely, especially as regards the proportionate mortality from pulmonary tuberculosis during the earlier years of life, which in a measure no doubt is directly attributable to the more effective safeguarding of young men employees and restrictive legislation against the employment of children underground. At the older ages the proportionate mortality from pulmonary tuberculosis in this country is apparently higher than in England, due possibly to a tendency in superficial clinical diagnoses to report deaths as phthisis which should more properly be returned as chronic bronchitis and asthma; or possibly the tendency may be the other way in England, to return deaths as bronchitis properly assignable to pulmonary tuberculosis. There are, however, reasons for believing that nontuberculous lung diseases are more common among the coal miners in this country than among those of England and Wales. The comparative statistics are further affected by climatic conditions and also by the fact that coal-mining accidents in this country are more common than in England. The Prudential statistics are strictly limited to coal miners and do not include other mine employees in so far as the fact is indicated on the death certificates. For the purpose of facilitating convenient comparison with corresponding proportionate mortality statistics for England and Wales Table 159 is included showing the details by divisional periods of life for nontuberculous respiratory diseases.

TABLE 159.—COMPARATIVE MORTALITY OF COAL MINERS FROM NONTUBERCULOUS RESPIRATORY DISEASES, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1907 TO 1914, BY AGE GROUPS.

Age at death.	Deaths from all causes.	Deaths from nontuberculous respiratory diseases.									
		Asthma.		Bronchitis.		Pneumonia.		Other.		Total.	
		Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
15 to 24 years	364	....	....	1	0.3	22	6.0	2	0.5	25	6.9
25 to 34 years	395	....	....	3	.8	26	6.6	3	.8	32	8.1
35 to 44 years	468	7	1.5	5	1.1	44	9.4	14	3.0	70	15.0
45 to 51 years	840	33	3.9	14	1.7	135	16.1	25	3.0	207	24.6
55 to 64 years	917	61	6.7	26	2.8	103	11.2	48	5.2	238	26.0
65 years and over	674	36	5.3	32	4.7	67	9.9	32	4.7	167	24.8
Total, 15 years and over	3,658	137	3.7	81	2.2	397	10.9	124	3.4	739	20.2

The table is particularly suggestive as indicating a relatively higher proportion of deaths from asthma than from bronchitis, and even for both diseases combined the averages fall below the corresponding averages for the coal miners of England and Wales. Unfortunately, the English statistics do not differentiate asthma. The mortality from pneumonia is apparently somewhat higher in this country, or 10.9 per cent in the Prudential experience, against 8.6 per cent in England and Wales.[1]

The Prudential experience is for coal miners in general, since a differentiation of even anthracite and bituminous miners has not been feasible. There are convincing reasons for believing that similar variations in the rate of frequency of the different forms of respiratory diseases, whether tuberculous or nontuberculous, would be met with in the principal coal-mining districts, but thus far no extended analysis has been made of the official statistics even for States in which local registration is approximately accurate and complete.[2] Occasional discussions in mining journals as regards the alleged long life of the mine worker, or the comparative freedom of

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[1] Since the comparative statistics of the mortality from tuberculosis and nontuberculous respiratory diseases for the United States and England and Wales are not generally accessible, the following table is included:

Comparative mortality from tuberculosis and nontuberculous respiratory diseases of the United States registration area and England and Wales, 1911 to 1915.

[Rate per 100,000 of population.]

Cause of death.	United States registration area.		England and Wales.	
	Males.	Females.	Males.	Females.
Tuberculosis of lungs	139.8	109.5	115.8	80.0
Acute miliary tuberculosis	5.2	4.7	11.2	9.3
Tuberculous meningitis	8.8	8.1	15.3	12.7
Tuberculosis of other organs	9.9	9.7	16.0	13.1
Disseminated tuberculosis	1.3	1.2	6.9	5.3
Tuberculosis, all forms	165.0	133.2	165.1	120.4
Bronchitis	17.1	19.5	144.7	109.4
Broncho-pneumonia	48.2	47.6	57.5	46.5
Pneumonia, lobar and unqualified	93.1	73.6	75.5	44.9
Pleurisy	4.0	3.0	4.9	3.0
Asthma and emphysema	3.0	2.7	7.6	4.7
Other respiratory diseases	7.9	6.9	18.0	15.7
All respiratory diseases	173.3	153.3	278.2	224.2

[2] An extended report on a "Sickness survey of principal cities in Pennsylvania and West Virginia" was published by the Metropolitan Life Insurance Co. of New York in 1917. This report includes comparative data for other communities previously investigated. According to this investigation, "among anthracite coal miners 15 years of age and over, the rate for sickness involving disability for work was 23.4 per 1,000. This rate was lower than that for disabling sickness for other male members of anthracite coal miners' families (25.9 per 1,000), about the same as the rate for disabling sickness among bituminous coal miners (23.9 per 1,000), a little more than the rate for other members of bituminous coal miners' families (22.2 per 1,000), and about five points per 1,000 more than the rate for disabling sickness among iron and steel mill employees aged 15 years and over. Anthracite coal miners between 25 and 34 years show a sickness rate of 13.1 per 1,000, which is about three points per 1,000 higher than the rates for disabling sickness in the group of other males of the same ages in anthracite families, about three points lower than the disabling sickness rate among bituminous coal miners of the same ages, and practically the same as the disabling sickness rate among iron and steel mill employees."

the coal miner from pulmonary tuberculosis, are practically valueless in that they are not with reference to ascertained facts, but based upon general assumptions and conditions superficially observed in foreign countries. An occasional obituary notice of an aged miner is erroneously construed into an argument in favor of the noninjuriousness of coal dust, or underground work, and in disregard of the fact that in the United States, for illustration, the proportion of coal miners at ages 45 and over is only 17.3 per cent of the total number employed, according to the census of 1910, against 29.3 per cent for all persons employed in agriculture. As observed in an editorial in the Coal Age for March 16, 1912, "the miner has always declared the mines unhealthy," but in curious contrast, the official and other evidence has been construed to the effect that mine labor, especially in coal mines, is not incompatible with the attainment of a normal average duration of life.

The mortality of coal miners has also been reported upon by the Metropolitan Life Insurance Co. in Bulletin 207 of the United States Bureau of Labor Statistics, on "Causes of Death by Occupation." This investigation includes 1,557 deaths of coal miners presented in detail by specified important causes in the table below:

TABLE 160.—NUMBER AND PER CENT OF DEATHS FROM SPECIFIED CAUSES AMONG COAL MINERS, BY AGE PERIODS, 15 YEARS AND OVER—WHITE MALES.

[Metropolitan Life Insurance Co.—Industrial department—Mortality experience, 1911 to 1913.]

Cause of death.	Ages 15 years and over.		Per cent of deaths during age period (years)—					
	Number.	Per cent.	15-24	25-34	35-44	45-54	55-64	65 and over.
Number of deaths	1,557	....	151	135	182	319	407	363
Influenza	23	1.5	0.7	....	1.6	0.6	2.2	2.2
Tuberculosis of the lungs	91	5.8	4.0	11.9	12.1	6.6	3.4	3.3
Cancer (all forms)	71	4.6	.7	1.5	2.7	3.4	6.9	5.6
Cerebral hemorrhage, apoplexy, and paralysis	94	6.0	.7	.7	1.6	4.1	7.6	12.4
Organic diseases of the heart	149	9.6	2.6	4.4	6.6	8.8	10.8	15.2
Acute and chronic bronchitis	49	3.1	....	....	1.1	1.6	4.2	6.9
Pneumonia (lobar and undefined)	161	10.3	4.6	7.4	10.4	14.7	11.3	8.8
Cirrhosis of the liver	37	2.4	....	.7	1.1	4.1	2.9	2.5
Bright's disease	116	7.5	....	1.5	6.6	7.8	11.5	8.3
Suicide (all forms)	18	1.2	.7	2.2	2.2	2.2	.7	....
Accidental violence	317	20.4	62.9	43.7	30.7	15.7	10.3	4.1
All other causes	431	27.7	23.2	25.9	22.9	30.4	23.0	29.9
Total	1,557	100.0	100.0	100.0	100.0	100.0	100.0	100.0

According to this experience the mortality from pulmonary tuberculosis was practically negligible at ages 15 to 24, having been only 4 per cent as compared with 33.8 per cent in all occupations. The relative index, therefore, was only 11.8. At ages 25 to 34, however, the proportionate mortality from pulmonary tuberculosis was 11.9 per cent against 40.9 per cent for all occupations, and at ages 35 to

44 it was only 12.1 per cent against a general average of 32.9 per cent. The mortality at the older ages was practically negligible. The experience, therefore, sustains the corresponding data of the Prudential, subject, however, to the conclusion that the two experiences in all probability are not strictly comparable. The experience of the Prudential is much more extensive and possibly more representative and less affected by methods of medical inspection and examination. The two companies in this respect do not follow precisely the same practice. The experience of both institutions, however, indicates conclusively a decidedly low proportionate mortality from pulmonary tuberculosis among coal miners in this country. The discussion by Dr. Dublin is, in part, as follows:

The low proportionate mortality from tuberculosis of the lungs among coal miners is a matter of general record. The data of the registrar general of England and Wales, and of Hoffman in his occupational mortality statistics of the Prudential, give very low indices for pulmonary tuberculosis; for all ages combined the data of the former show 64.5 and of the latter 50.7. The Metropolitan index of 28.3 is the least recorded. Coal miners seem to be relatively free from pulmonary tuberculosis at every age period from 15 years to 65. The death rates from tuberculosis of the lungs also point to this conclusion. Thus the registrar general of England and Wales reports that the death rate from phthisis among coal miners at the age period 15 to 24 is 70.6 per 100,000 living. This rate is 68.1 per cent of that prevailing for all occupied males.

The low tuberculosis rate among coal miners is, moreover, coupled with a high rate from accidental violence. This is characteristic of all age periods, but especially up to age 45. For all ages the relative indices are all over 300. The age period 45 to 54 has a relative index of 184.7; in the age period 55 to 64 the index is 158.5. In the last age period, 65 and over, it is only 93.2. The Prudential experience is very nearly the same as that of the Metropolitan; for all ages the relative index is 246.2. The index for the material of the registrar general's office is 256.9. The above figures show clearly the effect of the dangers of the occupation upon the mortality of coal miners.

The low proportionate mortality from tuberculosis of the lungs and the high proportionate mortality from accidental violence are closely related phenomena. It is evident that deaths from accidental violence, especially at the earlier ages, tend to decrease the number of deaths that would ordinarily have been reported from tuberculosis. The proportion of miners who die from accidents but who are also affected with tuberculosis can be determined only by a special investigation. It may at first thought appear that the low tuberculosis rate is a direct consequence of the high rate from accidents, and that we are really not concerned with a true immunity against tuberculosis in this occupation. The weight of much indirect evidence is, however, strongly in favor of the theory of such a relative immunity. Thus we find a high proportionate mortality from pneumonia among coal miners at all ages; the index is 143.1. After age 25 the index is uniformly higher than for all occupations. The same may be said with reference to the proportionate mortality from acute and chronic bronchitis after age 34. Coal miners, therefore, show a high representation of the respiratory diseases. This is clear even in the presence of the high accident rate.

The Prudential experience is, in a large measure, confirmed by the above statistics of the Metropolitan Life Insurance Co. for the period of 1911–1913, including 1,557 deaths of coal miners from all causes, of which 91, or 5.8 per cent, were from pulmonary tuberculosis. This is a much lower percentage than the corresponding mortality figure of 9.7 per cent for the Prudential experience, suggesting that in all probability the difference is to be accounted for by variations in the mining territory covered by the respective operations of the two companies. The proportion of deaths from pneumonia in the Metropolitan experience was 10.3 per cent, against 10.9 per cent for the Prudential, but the deaths from accidents were 20.4 per cent for the Metropolitan, against 24.2 per cent for the Prudential. The smaller proportion of deaths from pulmonary tuberculosis is maintained throughout every divisional period of life.

GENERAL CONCLUSIONS.

The preceding conclusions are based in part upon the alleged antagonistic properties of coal dust to the development of phthisis, and it is quite possible that a protective power is exercised by pure carbon dust in this particular, though rather limited, direction. But it is of no practical importance from a mortality point of view whether the injury done to the lungs results in a true tuberculosis, or in a form of nontuberculous, so-called miners' phthisis, which, according to all available statistical data, is of more than general frequency among the coal-mining population. The statement made by Sir Thomas Oliver, therefore, that in consequence of the better ventilation of coal mines at the present time, "the health of coal miners is satisfactory," and that this is particularly so as regards tuberculosis, must be accepted with reserve. The same author has directed attention to the statement made in the discussion on anthracosis, by Wainwright and Nichols, that the calcium salts in coal dust furnish a certain amount of protection to the lungs on account of their germicidal properties, in support of which it is said that it is astonishing, for example, how rapidly wounds in coal miners heal, and that tetanus is said to be exceedingly rare in the case of underground miners, which in part no doubt is attributable to the possible germicidal action of coal dust. Too much, however, must not be made of this fact, which can have but an indirect bearing upon the coal miners' increased liability to respiratory diseases, more or less seriously complicated by continuous and considerable coal-dust exposure. In the opinion of Sir Thomas Oliver, so far as coal miners' phthisis is concerned, "it may be stated that a collier who develops anthracosis may live for years and be little inconvenienced by his malady," but he also points out that in consequence of dust exposure serious damage is done to the ciliated epithelium of the trachea and bronchii, which act as a defensive barrier to the lungs, in that the dust caught in the mucus secreted by the tubes is, by the waving action of the ciliated epithelium, wafted outward; and that, therefore, the recurrent colds lead to a shedding of the ciliated epithelium and with this desquamation an important defense is lost to the lungs. "This circumstance," he concludes, "is not without importance since recurrent catarrh of the upper respiratory passages is a frequent prelude to pneumoconiosis." On this account alone there is evidence that there is a direct relation between dust and the excessive mortality from nontuberculous diseases, or from all respiratory diseases combined, whether tuberculous or otherwise, in view of the fact that the clinical diagnosis is frequently superficial and not sustained by postmortem. Sir Thomas Oliver is unquestionably correct in his statement that "in the case of the coal miner it is not the carbon particles of the coal but the stony particles to which the carbon particles are affixed which injure the lungs;" but in this case also the conclusion must not be carried too far, since at the present time no data are available regarding the true nature of a sufficient number of coal-dust samples with reference to mineral and even metallic impurities. The statistical evidence, however, is sufficient for the purpose, that coal mining, on account of dust exposure, requires to be included among the duty trades injurious to health, with a decided consequential predisposition to respiratory diseases, whether tuberculous or nontuberculous, as the case may be.

The only additional statistical information available regarding the mortality of coal miners in the United States is the combined collective experience of American life insurance companies, issued by the medico-actuarial committee. The experience, fortunately, is divided into anthracite and bituminous, but not with reference to the causes of death. The data are set forth in detail in Table 161, which indicates the ratio of the actual to the expected mortality, showing for the anthracite coal miners a ratio of 191 deaths actually experienced against 132 for the bituminous miners. How far the factor of occupational selection is of importance has not been determined. In all probability the average duration of insurance in bituminous coal fields is less than in the older anthracite fields. The experience for both classes is entirely too limited for a safe conclusion in that there are only 66 deaths of anthracite coal miners and 45 deaths of bituminous coal miners. The small number exposed to risk at the older ages is suggestive of extreme care in medical selection. The table, particularly for the younger ages, indicates that the general mortality of coal miners in the United States is distinctly above the average.

TABLE 161.—MORTALITY FROM ALL CAUSES AMONG COAL MINERS OF UNITED STATES (MEDICO-ACTUARIAL EXPERIENCE), BY AGE GROUPS.

Age at death.	Number exposed to risk.	Actual deaths.	Expected deaths.	Ratio of actual to expected deaths.
ANTHRACITE COAL MINERS.				
15 to 29 years	1,412	11	6.71	164
30 to 39 years	1,460	15	8.89	169
40 to 49 years	949	22	9.76	225
50 to 59 years	405	17	8.89	191
60 years and over	9	1	.30	333
Total	4,235	66	34.55	191
BITUMINOUS COAL MINERS.				
15 to 29 years	2,883	22	12.60	175
30 to 39 years	2,684	18	13.75	131
40 to 49 years	738	4	6.00	67
50 to 59 years	106	1	1.79	56
60 years and over	3	....	.08	....
Total	6,414	45	34.22	132

In concluding these observations mention should be made of the observations by Hayhurst, which have reference to the bituminous coal mines of Ohio. No field investigation of the coal-mining industry was made by the division of occupational diseases, but it is said that the principal occupational afflictions to which miners in the types of mines which are worked in Ohio are most liable are: "Respiratory diseases (pneumonia, anthracosis, pulmonary cirrhosis, emphysema, phthisis, pleurisy, and middle-ear disease), hookworm disease, typhoid fever, trachoma or granulated eyelids, nystagmus or dancing pupils, 'beat hand,' 'miners' elbow,' while the effects of sulphur fumes upon the lungs, skin, and eyes should be inquired into."

Reference is made to the Ohio vital statistics for the three years 1910–1912, according to which out of 1,484 deaths of miners from all causes, 114, or 7.68 per cent, were deaths from pulmonary tuberculosis. The corresponding proportion for farm labor was 7.13 per cent. The average age at death of 464 coal miners in Ohio in the year 1911 was 49.3 years. These observations are in general conformity to the results of other investigations, but they obviously fall far short of the required scientific conclusiveness. The coal-mining industry is of such vast importance to the Nation, and to the large number of men employed in the industry, that there is the utmost urgency for a strictly scientific inquiry into the facts of disease preindustry is of such vast importance to the Nation and to the large economic loss on account of an excess in the death rate from all causes, and from respiratory diseases, whether tuberculous or otherwise, in particular. Aside therefrom there is unquestionably also a very considerable amount of needless premature invalidity, as is clearly shown by the experience of German miners' associations, and to a lesser extent by the investigations made by life insurance companies in the United States.[1] It is, therefore, to be hoped that future investigations, medical or statistical, will be made with a due regard to more exacting requirements, so that the existing amount of superficial information, more or less misleading, may be replaced by trustworthy data and conclusions which bear the stamp of scientific accuracy and impartiality.[2]

QUARRYING.

The quarrying industry, according to the report of the Bureau of Mines for 1915, gave employment to 100,740 persons, among whom there occurred 148 fatal accidents, or 1.80 per 1,000 300-day workers, compared with 3.89 for metal mines and 4.44 for coal mines.[3] The relative importance of the accident factor in its relation to the mortality from disease is, therefore, obviously of lesser importance in this branch of the mining industry. The vital statistics of quarrymen are as a rule combined with the mortality data of stone workers, so that only the most general conclusions can be drawn from the available data.

Parry, in his treatise on the "Risks and dangers of occupations," observes that—

> Quarrymen engaged in taking out stone, slate, etc., have a high death rate, 582 compared with 402 for all males from lung diseases, the danger of the occupation varying with the physical and chemical properties of the dust created. In the various operations for obtaining alabaster, graphite, and china clay the particles produced are not sharp or angular, and the effects of inhalation consequently not so very serious. It may here be noticed that the minute fragments of graphite are also breathed in during the manufacture of lead pencils.

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[1] For the essential facts of what is perhaps the most successful and important of modern social institutions established for the progressive betterment of the conditions of mine labor and life, and the mitigation of the economic hardships resulting from the more or less inevitable casualties in the mining of coal, see "German Miners' Insurance and Annuity Funds," by F. L. Hoffman, published in The Engineering and Mining Journal, Vol. 90, Nos. 18, 19, 20, and 21 (New York, Oct. 29, Nov. 5, 12, and 19, 1910).

[2] On account of the increasing attention which is being given to the use of powdered coal as fuel, it is a foregone conclusion that the subject of coal dust in its relation to health will require more extended consideration in the future. The technical aspects of the manufacture of powdered coal for fuel are set forth in a discussion by Harry Holmes in the Scientific American for April 18, 1914, and with reference to briquetting methods a Belgian process is described by the late Lindon Bates, jr., in the Scientific American Supplement for December 10, 1910. The handling of coal dust at a coal washery, in conformity to modern methods, is described by J. Drummond Paton in the Coal Age for October 18, 1913. The hygienic aspects of dust control in anthracite breakers are set forth by J. J. Jones in the Engineering and Mining Journal of April 2, 1910.

[3] United States Bureau of Mines, Technical Paper 168, p. 51.

> In chalk and limestone quarries the work is carried out so much in the open air that the dust is largely got rid of before it is inhaled, and the occupation does not appear to be a very risky one. Slate quarrying is the most formidable of all, as here the atoms are so sharp and pointed, and it is among those who are occupied in the sawing and dressing of the stone, where the dust is specially freely produced, that lung disease is most rampant. The only special remark as to prevention is this: During operations in which most dust is created, respirators should be worn.

These observations can not be considered conclusive, and the recommendation regarding the general use of respirators is inapplicable to most of the important processes in the quarrying industry.[1] Lloyd, in his treatise on "Diseases of occupations," largely with reference to American conditions, points out that—

> Stonecutters and quarrymen suffer in various degrees from the inhalation of dust. The extent of the evil in their cases depends upon, first, the character of the dust, and, second, the circumstances amid which the work is pursued. Quarrymen are liable to accidents and to the effects of very hard labor. If they work underground or in deep quarries they may suffer with the effects of dampness. The quality of the stone has much to do with the extent of pulmonary disease among stonecutters. Some stone is much more dusty than others. A sedimentary stone, for instance, that was formed originally simply by the deposit of earthy and silicious particles under water is much more liable to give off a large quantity of dust than is a stone that was fused in early geological ages—the igneous stones, for instance, like granite. Although the particles from these stones are exceedingly hard, there is not much true dust, only the particles actually displaced by the contact with the tool being thrown off. These probably do not carry far in the air, and are mostly too large to gain access to the alveoli as dust. This was the explanation given by Hamilton, of Aberdeen (quoted by Arlidge), for the fact that the masons and polishers at the Aberdeen quarries do not suffer much if any with industrial phthisis.

Lloyd combines stonecutters and quarrymen in a broad generalization, which is obviously unscientific in view of the widely varying conditions under which quarrying methods proper are carried on as separate and distinct from the millwork, which consists chiefly in the sawing, cutting, and polishing of the stone. His observation, however, that the quality of the stone has much to do with the extent of pulmonary disease among stonecutters is equally applicable to quarrymen, although the latter unquestionably suffer decidedly less from the risk of dust inhalation, chiefly on account of the fact that most of the work is carried on in the open air.

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[1] See in this connection the "Elements of Mining and Quarrying," by Sir C. Le Neve Foster, London, 1903; also an exceptionally interesting though brief discussion on "Quarrying hazards," in the Travelers' Standard, April and May, 1917; an earlier but still very useful account of quarrying methods by F. W. Sperr is included in the report on Building Stones and the Quarrying Industry of the Tenth Census. Except to the extent that new methods have been introduced into the industry during the intervening period of time this account is still one of the most useful for practical purposes. Reference, however, requires also to be made to Census Bulletin 45, Washington, 1891, in which the methods of quarrying are described with reasonable thoroughness. A descriptive account of present-day methods is by Frank C. Perkins, Scientific American Supplement No. 2118, August 5, 1916.

A fairly comprehensive discussion of the health of quarrymen with special reference to the conditions of employment, by Brown and Kelynack, is included in Oliver's Dangerous Trades. A quarry is defined as "an excavation, pit, or place from which stone or rock material is separated by digging, cutting, blasting, or similar processes." This definition includes most, but not all, forms or methods of rock excavation in which hand and power drills are extensively and frequently exclusively employed. Quarrying includes a larger variety of stone products than the stone industry separately considered, when the term "quarrying" is made to include the common methods of rock crushing, which are unquestionably among the most unhealthy branches of the industry. This conclusion applies especially to trap rock, which is quarried and crushed on a large scale for road-building purposes. The term, however, is not applicable to tunneling, which is more properly a branch of the mining industry. According to Brown and Kelynack, "the quarryman, from the nature of his work and the circumstances under which it is carried on, is necessarily exposed to influences which may (1) excite or (2) predispose to morbid conditions, and in not a few cases it is difficult, if not impossible, to sharply distinguish between them." Aside from the obvious liability to serious and fatal accidents, the subject of disease frequency is referred to with special reference, of course, to prevailing conditions in the United Kingdom, in part as follows:

> After having made extensive inquiries with a view to ascertain the extent of actual disease which may be fairly considered as incidental to quarrying, we are drawn to the conclusion that such work, generally speaking, is not necessarily detrimental to health. The medical officers and managers of most of the large quarries from whom we have sought information are decisive in considering quarrying, as usually carried out in this country, a fairly healthy occupation. Of course quarry workers are liable to many ailments to which all laborers are more or less prone, and their habits and social customs are not always such as to maintain a high degree of physical vigor. Unfortunately, in many parts the quarrymen are thriftless and drunken. Their homes also are often ill built and ill kept. A neglect of habits of cleanliness is, in many instances, only too apparent. In some parts of the country the quarrymen are of poor physique, which arises, according to local opinion, from too early marriage, intermarriage, excessive tea drinking, and poor diet.

In continuation, it is said that quarrying is by no means an employment dangerous to health, as is made evident by the fact that in many quarry districts old men abound, many of whom work until over 80 years of age. This observation is likely to be misleading, on account of the comprehensive nature of the quarry industry. Unquestionably much of the work, especially when carried on without the use of power drills, is not distinctly injurious to health, and old men may safely be employed in processes not involving serious physical strain. Since most of the work in connection with quarries is carried on in the open air, there are frequently decided physical advantages, but notwithstanding these, the general statistical evidence for the United Kingdom and, as far as available, for the United States is quite conclusive that the mortality from pulmonary tuberculosis among quarrymen, considered as a group, is distinctly above the normal. Brown and Kelynack, in continuation of their observations on the diseases of quarrymen, with special reference to the respiratory organs, observe that—

> Lesions in connection with the lungs and air passages have long and rightly been considered the more particular accompaniment of work associated with the production of dust. But in most forms of quarrying the amount of dust and its means of access to the respiratory tract must be considered so limited that serious pulmonary disease is quite the exception.
>
> Where, however, in connection with quarry works there is also extensive dressing of soft material like sandstone or the preparation of material giving rise to such irritating particles as granite, changes in the bronchi and lungs are liable to occur. The bronchi then become the seat of an excessive formation of mucus, and it may be that a catarrhal process is established which may progress to a chronic bronchitis, to which will sooner or later be added the usually associated conditions.
>
> The lungs may absorb more or less of the dust particles which, becoming deposited in the interalveolar and subpleural lymphatics, or arrested in the bronchial glands, give a greater or less degree of pigmentation to the lung (pneumoconiosis). Should, however, as is very likely, the particles of stone dust produce marked irritation, the reaction of the tissues will lead to the formation of fibrous tissue which may not only lessen the function of the lungs as blood-aerating organs but predispose them to the invasion of the tubercle bacillus.

It is difficult to understand how, in view of the foregoing and the readily ascertainable facts of the conditions under which the industry is carried on, the authors of the preceding observations should conclude that, "Quarry workers would appear to be but little predisposed to tuberculosis, and doubtless the outdoor character of the work greatly militates against the liability to infection."

According to the available occupation mortality statistics for England and Wales (1900–1902), quarrymen, chiefly with reference to stone and slate, considered as a group and numbering, according to the last census, 71,450, experienced a general death rate slightly above the standard for occupied males at ages 15 to 25 and 55 to 65 years. In the main working time of life their comparative mortality figure was 6 per cent less than the standard. The mortality from respiratory diseases and from phthisis was "no less than 70 per cent above the standard." Comparing the data for 1900–1902 with previous years, it appears that the death rate from all the principal causes had declined, but regardless of the diminution, including a reduction in the mortality from phthisis, the most recent statistics reemphasize the earlier conclusion of a substantial excess in the death rate of quarrymen from pulmonary tuberculosis.

AMERICAN MORTALITY EXPERIENCE.

For the United States there are no recent statistics generally applicable to the problem under consideration other than the experience of the Prudential Insurance Co. of America, limited, however, to only 149 specified deaths of quarry employees from all causes; and of this number only 22, or 14.8 per cent, were from pulmonary tuberculosis. The experience is set forth in the usual form in Table 162.

TABLE 162.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG QUARRY WORKERS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1907 TO 1914, COMPARED WITH THAT OF ALL MALES IN THE UNITED STATES REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of quarry workers, 1907 to 1914, from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Quarry workers.	Males in registration area, 1900 to 1913.
15 to 24 years	12	2	16.7	27.0
25 to 34 years	12	1	8.3	30.5
35 to 44 years	26	6	23.1	23.4
45 to 54 years	27	4	14.8	14.7
55 to 64 years	39	8	20.5	7.9
65 years and over	33	1	3.0	2.6
Total, 15 years and over	149	22	14.8	13.9

This table can not be considered entirely conclusive, but it is quite suggestive that the apparent mortality from pulmonary tuberculosis in this group should have been in such close conformity to the normal mortality of males in the registration area. When, however, separately considered, particularly at the ages over 55, there is apparently a tendency toward an excess in the proportionate mortality from pulmonary tuberculosis which it is reasonably safe to assume would upon the basis of a more extensive inquiry be found even more pronounced than is the case in the rather limited experience available.

DUST HAZARDS OF THE QUARRYING INDUSTRY.

The inclusion of certain branches of the stone industry under quarrying has seemed preferable to the consideration of the hygienic aspects of such employments under specified trades with exposure to mineral dust. The technology of quarrying is extremely involved, and the preceding conclusions must be accepted with reserve, and, as regards the different branches of the quarrying industry, they are subject to the more extended consideration of the dust hazards in the several branches of the stone industry. Stone, in all of its forms, contains varying proportions of impurities, both metallic and mineral, which, under given conditions, may seriously complicate the statistical consideration of the question as to how far any particular stone material is directly injurious to health and a predisposing cause of pulmonary tuberculosis. The hygiene of quarrying has not been made a subject of extended and qualified inquiry, but a most useful contribution to the technology of marble quarrying, with carefully considered observations on quarrying methods, including the removal of the over-burden, the drilling of the holes, and the subsequent millwork and finishing of the stone product, has been made public by the United States Bureau of Mines. Additional information of value is contained in a number of special reports of the United States Geological Survey, chiefly on the granites of New England and the Southeastern Atlantic States. The mortality of stonecutters as a class has also been considered by the Massachusetts State Board of Health, according to which, for the year 1907, of the mortality among stonecutters in the Quincy district 41 per cent of the deaths were from pulmonary tuberculosis, and approximately the mortality from this disease among stone and marble cutters and carvers was five times greater than among farmers or lumbermen.[1] The Ohio State Board of Health in the January, 1914, Bulletin (p. 99) takes occasion to point out in this connection that—

A man doing ordinary work breathes 21 cubic feet of air per hour. If this air is saturated with dust, gases, or poisons he also breathes them. In our modern methods of drilling rock, slate mining, quarrying, and stonecutting, men breathe no end of pernicious dust. The English found that rock drillers, who have no protection, average 8 to 10 years at the trade, and their average age at death is 35 years. The harder the rock the more the danger. Those who work piecework succumb the soonest. Death is principally due to pneumonia and consumption. One-fourth of the weight of the lungs of a rock driller at death has been found to be due to silica—that is, inhaled rock dust.

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[1] The occurrence of lung diseases among quarrymen is the subject of an interesting editorial in the British Medical Journal of March 23, 1912. With reference to conditions in Shropshire, it is said that—

> The stone contains 95.4 per cent of silica. On microscopical examination the particles of stone are found to vary from 1/100 to 1/600 of an inch in diameter. Some of the particles are rounded and transparent, others are sharp and angular.

As to the menace of dust inhalation Dr. Wheatley is quoted in the statement that—

> In guttering the stone considerable quantities of dust are inhaled, as the men have to lean forward and bend closely down upon their work. As the quarrymen have good homes, live in a healthy district, receive wages above the average working population, and are on the whole a temperate class, the high mortality rate from phthisis among them must be largely the result of their occupation. Some of the men retire from the quarries and stone work after a few years. Most of the men in the district who are alive after 60 have not worked exclusively in stone. Taking the average annual death rate from phthisis per 1,000 for 31 years, quarrymen give 7.94 and masons 16.71, whereas the death rate of males over 20 years of age from phthisis in the same district is only 1.47, a figure which compares most favorably with the phthisical death rate of males over 20 years of age for 1901 in England and Wales, which was 2.37. The high death rate from phthisis of stoneworkers, which is seven times greater than that of the other people of the county, can only be explained by the dusty nature of the occupation.

Employers should cooperate in lessening the incidence of these diseases among this class of workers by (1) employing men of sound constitution, and particularly should attention be given to this point in case of youths; (2) inform the men of the dangerous character of this work; (3) arrange for periodic medical examinations; (4) all machine planing, as well as sawing, should be done in the wet (perhaps using mineral oil); (5) stonemasons' sheds should be cleaned out and made free from dust each day; (6) openings to the shed should be at the floor or not higher than 3 feet from the floor, so that the dust, which is rather heavy, will not rise to the breathing level when it is blown out; and (7) where mechanical power is used fans should be installed and air delivered above the head of the men so that the dust is blown downward, while locally applied exhaust systems can be used in several processes of the work. The employee should breathe only through his nose, and, when inhalation of dust is unavoidable, should wear a wet sponge or other form of respirator. All the schools in a stone area should give special lessons on the danger of dust, upon proper methods of breathing, while medical school supervision would find the cases of obstructed nasal breathing during youth.

Additional evidence seems hardly necessary to emphasize the seriousness of the dust hazard in the quarrying industry, irrespective of the material extracted or the methods employed, except in so far as the degree of injuriousness is invariably increased by the more or less extensive use of pneumatic tools.[1]

VITAL STATISTICS OF CENTERS OF GRANITE INDUSTRY.

Quarrying is, of course, the preliminary extraction process in the stone industry. The more important aspects of the stone dust exposure have been elsewhere discussed in some detail, but it has seemed advisable to bring together for the present purpose some rather interesting statistics of the mortality from pulmonary tuberculosis and from other respiratory diseases in the centers of the American stone industry, with special reference to the nature of the stone product quarried. Table 163 exhibits the mortality of the centers of granite production, by counties, in the States of Maine, New Hampshire, and Vermont. In each case the county referred to as a granite center is such as is specifically made note of in the annual reports of the United States Geological Survey on the stone industry.[1] Of course, in some counties the industry is of much greater predominating importance than in others.

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[1] See in this connection the report elsewhere referred to "On the Prevalence of Phthisis among Quarry Workers and Miners," by Sidney Barwels, M. D., county medical officer, Derbyshire, 1913; also an address on "Quarrying," by S. Le Neve Foster, Journal of the Sanitary Institute, London, 1894.

TABLE 163.—MORTALITY FROM PULMONARY TUBERCULOSIS AND FROM OTHER RESPIRATORY DISEASES IN THE CENTERS OF THE GRANITE INDUSTRY, 1909 TO 1913.

Locality.	Pulmonary tuberculosis.		Other respiratory diseases.	
	Per cent of deaths from all causes.	Death rate per 100,000.	Per cent of deaths from all causes.	Death rate per 100,000.
Hancock County, Me	6.8	104.6	11.7	180.4
Kennebeck County, Me	7.4	133.6	12.5	226.5
Augusta	7.9	194.1	12.8	316.5
Waterville	8.9	136.8	14.7	225.7
Rural	6.7	111.4	11.7	195.2
Knox County, Me	8.4	145.7	8.7	152.4
Lincoln County, Me	6.4	102.0	9.1	144.1
Waldo County, Me	7.0	121.1	10.1	174.4
Washington County, Me	9.6	137.0	11.5	165.2
Maine granite counties	7.7	126.9	11.1	183.8
State of Maine	7.0	110.8	12.1	192.9
Carroll County, N. H	4.9	82.5	12.3	206.8
Hillsboro County, N. H	6.6	115.3	12.6	218.3
Manchester	6.5	113.9	13.9	242.5
Nashua	5.8	95.2	11.7	191.1
Rural	7.5	136.3	10.1	184.0
Merrimack County, N. H	6.8	128.0	9.8	186.0
Concord	6.0	128.0	8.9	189.6
Rural	7.4	128.0	10.6	183.5
New Hampshire granite counties	6.5	116.0	11.7	208.6
State of New Hampshire	6.2	105.0	11.6	196.7
Caledonia County, Vt	5.9	94.5	11.5	182.2
Windsor County, Vt	4.3	79.6	11.6	213.2
Vermont granite counties	5.0	86.6	11.5	198.6
State of Vermont	5.8	91.8	11.7	183.1
Summary.				
All granite counties	6.9	117.4	11.4	196.2
States of Maine, New Hampshire, and Vermont	6.5	104.7	11.9	191.7

Combining all the counties in which the granite industry in the three States is of sufficient local importance, it appears that the mortality rate from pulmonary tuberculosis as well as from other respiratory diseases is not very materially above the average for the States, considered as a group; and the same conclusion applies to the proportionate mortality for respiratory diseases other than pulmonary tuberculosis, which, in fact, is slightly lower. Some very important differences, however, are shown in the larger centers of the granite industry in Maine, as, for illustration, at Augusta, where the death rate from pulmonary tuberculosis is 194.1 per 100,000, against 110.8 for the State as a whole. The mortality of Augusta from other respiratory diseases is also extremely high, or 316.5 per 100,000, against 192.9 for the State as a whole.[1] Somewhat similar are the conclusions for certain granite-producing counties considered in detail for the States of New Hampshire and Vermont. This method of analysis is at present the only available means of arriving at approximately accurate conclusions, since thus far no investigation of the subject has been made by Federal or State authority or by a detailed analysis of life insurance experience.

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[1] For a strictly scientific discussion of "The Commercial Granites of Massachusetts, New Hampshire, and Rhode Island, with Maps and Illustrations," see Bulletin No. 354, of the U. S. Geological Survey, Washington, 1908. See also a separate discussion of "The Granites of Vermont," by the same author, in Bulletin No. 404 of the U. S. Geological Survey, Washington, 1909. For a discussion of Safety in Stone Quarrying, with observations on ventilation, etc., by Oliver Bowles, see Technical Paper 111, Bureau of Mines, Washington, 1915.

VITAL STATISTICS OF CENTERS OF MARBLE INDUSTRY.

The geographical distribution of the marble industry for the States for which official vital statistics are available is very limited, and the data for the State of Vermont are of most value. Table 164 shows that in the Barre district, which is the center of the Vermont marble industry, both the proportionate and the relative mortality from pulmonary tuberculosis are decidedly above the average for the State as a whole; in fact, it is extremely suggestive that even for all the marble counties combined the excess in the mortality from pulmonary tuberculosis should be as pronounced as is actually the case.

TABLE 164.—MORTALITY FROM PULMONARY TUBERCULOSIS AND FROM OTHER RESPIRATORY DISEASES IN THE CENTERS OF THE MARBLE INDUSTRY, 1909 TO 1913.

Locality.	Pulmonary tuberculosis.		Other respiratory diseases.	
	Per cent of deaths from all causes.	Death rate per 100,000.	Per cent of deaths from all causes.	Death rate per 100,000.
Bennington County, Vt.	4.7	70.4	11.2	166.3
Franklin County, Vt.	6.4	94.5	11.1	164.3
Grand Isle County, Vt.	8.9	108.8	12.0	146.9
Washington County, Vt.	9.1	136.6	12.1	181.4
Barre	18.5	239.7	11.8	152.5
Rural	6.4	100.3	12.2	191.6
Vermont marble counties [1]	7.3	108.8	11.6	171.6
State of Vermont	5.8	91.8	11.7	183.1

[1] Exclusive of Rutland County, which will be found under slate counties. This county shows an excessive rate over the rate for the State as a whole.

In the Barre district the proportionate mortality from pulmonary tuberculosis is 18.5 per cent against only 5.8 per cent for the State as a whole; while the relative mortality per 100,000 of population is 239.7 for Barre against 91.8 for the State. In contrast, however, the proportionate mortality from other respiratory diseases is about normal, while the death rate from this group of diseases for Barre is below the average for the State. Here again the averages are merely approximate, and they must be made use of with extreme caution.

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[1] How far these rates are affected by local hospitals or institutions can not be stated, but the possibility of such an effect should not be lost sight of.

VITAL STATISTICS OF CENTERS OF SANDSTONE INDUSTRY.

The centers of the sandstone industry are chiefly in the States of New York, Ohio, and Pennsylvania. Combining the returns for all the sandstone counties, both the proportionate and the relative mortality from pulmonary tuberculosis are below the averages for the States considered as a group; but there are, however, some exceedingly interesting and suggestive exceptions to this conclusion, particularly in the case of the Rome district in Oneida County, N. Y., where the relative rate from pulmonary tuberculosis is 264.9 per 100,000 against 152.3 per 100,000 for the State of New York. But the corresponding mortality from other respiratory diseases is somewhat below the average. The mortality from respiratory diseases in some sections is relatively high, but throughout the data brought together are not distinctly suggestive of a pronounced excess in the mortality of the counties which are representative of the sandstone industry, as being above the average for the remainder of the territory under consideration. The details for the sandstone centers are given in Table 165.

TABLE 165.—MORTALITY FROM PULMONARY TUBERCULOSIS AND FROM OTHER RESPIRATORY DISEASES IN THE CENTERS OF THE SANDSTONE INDUSTRY, 1909 TO 1913.

Locality.	Pulmonary tuberculosis.		Other respiratory diseases.	
	Per cent of deaths from all causes.	Death rate per 100,000.	Per cent of deaths from all causes.	Death rate per 100,000.
Orleans County, N. Y.	7.2	105.5	9.2	133.5
Oneida County, N. Y.	7.8	138.5	12.7	225.7
Rome	12.6	264.9	9.1	192.0
Utica	7.3	136.4	13.7	257.0
Rural	6.3	95.9	12.9	197.1
New York sandstone counties	7.7	132.9	12.2	210.0
State of New York	9.9	152.3	14.0	215.7
Cuyahoga County, Ohio	8.5	115.6	11.7	159.0
Cleveland	8.7	119.2	11.9	163.6
Lakewood	7.6	81.3	9.3	100.1
Rural	7.5	91.0	10.9	131.6
Lorain County, Ohio	6.7	83.4	10.7	132.5
Lorain	6.1	76.2	11.3	141.8
Elyria	6.0	74.5	10.1	125.9
Rural	7.7	94.5	10.4	127.0
Ohio sandstone counties	8.4	112.1	11.6	153.2
State of Ohio	9.2	122.6	10.4	138.4
Clearfield County, Pa.	4.2	47.8	14.5	166.3
Fayette County, Pa.	5.0	71.2	14.9	210.4
Connellsville	6.9	94.0	11.7	158.5
Uniontown	5.1	79.1	10.7	165.7
Rural	4.9	68.9	15.5	218.0
Mercer County, Pa.	5.7	73.1	11.1	142.0
Sharon	7.5	102.1	12.5	170.2
Rural	5.2	64.9	10.6	134.1
Westmoreland County, Pa.	4.9	62.5	13.0	167.1
Greensburg	4.6	77.1	11.0	185.5
Monessen	5.5	60.2	18.5	203.5
Rural	4.9	61.9	12.9	164.3
Pennsylvania sandstone counties	4.9	64.4	13.6	177.1
State of Pennsylvania	7.7	112.5	13.3	194.5
Summary.				
All sandstone counties	7.0	96.6	12.4	170.9
States of New York, Ohio, and Pennsylvania	9.0	131.6	13.0	191.2

VITAL STATISTICS OF CENTERS OF LIMESTONE INDUSTRY.

In curious contrast, more definite indication of health-injurious conditions is brought out by an analysis of the statistics for the limestone counties of Kentucky, Missouri, and Indiana as shown in Table 166.

TABLE 166.—MORTALITY FROM PULMONARY TUBERCULOSIS AND FROM OTHER RESPIRATORY DISEASES IN THE CENTERS OF THE LIMESTONE INDUSTRY, INDIANA (1909 TO 1913), KENTUCKY AND MISSOURI (1911 TO 1913).

Locality.	Pulmonary tuberculosis.		Other respiratory diseases.	
	Per cent of deaths from all causes.	Death rate per 100,000.	Per cent of deaths from all causes.	Death rate per 100,000.
Warren County, Ky.	14.9	225.7	9.0	136.7
Kentucky	14.3	186.6	10.0	130.6
Jasper County, Mo.	13.2	161.2	12.1	147.4
Missouri	10.3	131.3	11.6	146.8
Lawrence County, Ind.	12.5	165.3	9.9	131.3
Monroe County, Ind.	12.6	161.8	10.2	131.4
Indiana	10.1	132.8	9.7	127.6
Summary.				
Limestone counties	13.2	174.4	10.4	136.7
States of Kentucky, Missouri, and Indiana	11.1	144.6	10.4	134.6
Per cent of mortality excess in limestone counties	18.9	20.6	....	1.6

In all of the counties combined both the proportionate and the relative mortality from pulmonary tuberculosis are above the average, while the mortality from other respiratory diseases is about the same. There is an extraordinary excess in the mortality from pulmonary tuberculosis in Warren County, Ky., as well as in Jasper County, Mo., where, however, the situation is complicated by the zinc and lead-mining industries. (See p. 360.)

VITAL STATISTICS OF CENTERS OF BLUESTONE INDUSTRY.

In the case of all the counties under consideration the mortality from respiratory diseases other than pulmonary tuberculosis is relatively normal. The counties in which the bluestone industry is of importance in the States of New York and Pennsylvania show rather a lesser mortality, with, however, a rather important exception at Kingston, in Ulster County, N. Y., where the industry is thoroughly well represented, the mortality rate from pulmonary tuberculosis being 205.6 per 100,000, against 152.3 for the State. The mortality from other respiratory diseases, however, is both proportionately and relatively below the average. In Pike County, Pa., the relative mortality from pulmonary tuberculosis is 125.9 per 100,000, which compares with 112.5 per 100,000 for the State as a whole. All the bluestone counties combined, however, show a lower proportionate and relative mortality from pulmonary tuberculosis than the States considered as a group. The same conclusion applies to other respiratory diseases. The details for the bluestone industry are given in Table 167.

TABLE 167.—MORTALITY FROM PULMONARY TUBERCULOSIS AND FROM OTHER RESPIRATORY DISEASES IN THE CENTERS OF THE BLUESTONE INDUSTRY, 1909 TO 1913.

Locality.	Pulmonary tuberculosis.		Other respiratory diseases.	
	Per cent of deaths from all causes.	Death rate per 100,000.	Per cent of deaths from all causes.	Death rate per 100,000.
Delaware County, N. Y.	4.9	70.8	11.4	166.7
Ulster County, N. Y.	9.0	140.7	12.2	189.2
Kingston	10.9	205.6	9.5	180.3
Rural	8.1	115.1	13.5	192.8
New York bluestone counties[1]	7.7	117.6	11.9	181.8
State of New York	9.9	152.3	14.0	215.7
Pike County, Pa.	8.5	125.9	13.7	201.4
Susquehanna County, Pa.	5.3	81.7	12.4	192.2
Wayne County, Pa.	7.4	101.0	10.9	148.3
Wyoming County, Pa.	4.2	57.5	11.9	160.7
Pennsylvania bluestone counties	6.1	87.7	12.0	173.4
State of Pennsylvania	7.7	112.5	13.3	194.5
Summary.				
Bluestone counties	7.1	105.8	11.9	178.5
States of New York and Pennsylvania	8.9	134.2	13.7	206.0

[1] Sullivan County, N. Y., is a large producer but was left out because of the tuberculosis sanatoria at Liberty.

VITAL STATISTICS OF CENTERS OF SLATE INDUSTRY.

Finally, as regards slate-producing counties, the data are also far from conclusive. The details for the centers of the slate industry in Pennsylvania, New York, and Vermont are shown in Table 168.

TABLE 168.—MORTALITY FROM PULMONARY TUBERCULOSIS AND FROM OTHER RESPIRATORY DISEASES IN THE CENTERS OF THE SLATE INDUSTRY, 1909 TO 1913.

Locality.	Pulmonary tuberculosis.		Other respiratory diseases.	
	Per cent of deaths from all causes.	Death rate per 100,000.	Per cent of deaths from all causes.	Death rate per 100,000.
Washington County, N. Y.[1]	5.6	88.3	12.3	191.1
State of New York	9.9	152.3	14.0	215.7
Lehigh County, Pa.	7.4	116.6	11.3	179.2
Allentown	7.7	118.9	9.6	149.4
Rural	7.1	114.6	12.7	204.8
Northampton County, Pa.	6.6	96.1	12.2	177.2
Easton	6.4	105.2	10.9	180.7
South Bethlehem	6.8	105.8	14.6	226.0
Rural	6.6	89.9	12.0	162.3
Pennsylvania slate counties	7.0	106.1	11.7	178.2
State of Pennsylvania	7.7	112.5	13.3	191.5
Rutland County, Vt.[1]	6.4	98.7	12.0	184.3
Rutland	5.9	100.0	10.4	176.9
Rural	6.6	98.2	12.7	187.2
State of Vermont	5.8	91.8	11.7	183.1
Summary.				
Slate counties	6.7	102.5	11.8	181.3
States of New York, Pennsylvania, and Vermont	8.8	133.3	13.6	205.6

[1] These counties are adjoining and the same slate veins are mined.

There is apparently no very clearly defined relation in the general mortality from pulmonary tuberculosis and respiratory diseases in the slate-producing counties when comparison is made with the States under consideration or the States considered as a group. There are, however, some important exceptions. The general mortality of a given section, unless very pronounced, is not likely to be materially affected by the specific, even though quite excessive, mortality of some occupational group subject to more or less injurious exposure to irritating dust. The number of persons employed in distinctly health-injurious processes in most communities is usually relatively so small that the health-injurious consequences of special conditions become obscured by the numerically much more important general circumstances affecting the health and life of the community at large.

METALLURGICAL INDUSTRIES.

The mortality and the disease liability of men employed in the metallurgical industries and in the occupations supplementary thereto, essential to ore milling or other concentration processes, have not been made the subject of a sufficiently extensive investigation in this or other countries to furnish data of sufficient intrinsic, scientific conclusiveness applicable to American problems of health and industry.[1] According to the last annual report of the United States Bureau of Mines on metal mine accidents the number of persons employed in ore milling and related concentration processes during the year 1915 was 18,564, and in addition thereto the number employed at smelters was 31,327. The industry considered in the aggregate is one of extreme complexity and of widely varying labor and sanitary conditions. All mineral products are as a rule subject to preliminary breaking or crushing processes, in connection with which a large amount of finely comminuted dust is produced, which, according to its chemical or mechanical properties, must necessarily prove more or less injurious to health. The dust hazard is probably of least importance in connection with hand picking or sorting, much of which is frequently done underground, but in the large majority of cases the picking or sorting is carried on in the rock house and in the mills.[2] In modern plants the picking is done chiefly at movable or continuous belts at which the dust hazard is probably of lesser importance than in connection with subsequent crushing and concentration processes. For rock-grinding purposes a large variety of special mills of widely varying construction have been evolved in the progress of ore dressing, from the primitive arrastra to the most modern so-called

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[1] For practical details of American ore dressing, see "A Text-Book of Ore Dressing," by Robert H. Richards, S. B., LL. D.; New York, 1909.

[2] For a brief but useful account of "Mill and Smelter Methods of Sampling," by H. J. Stander, see Bulletin No. 26, Metallurgical Series No. 1, University of Arizona, Tucson, 1915-16.

Chili-Huntington mills. Probably the most serious dust hazard is in connection with so-called sampling processes, in which the material to be subjected to subsequent analysis by assaying or otherwise is reduced to the finest possible comminuted condition. In such sampling processes the nature of the gangue or rock material is of much greater importance than the metallic content, and perhaps the most typical illustration of such sampling methods is in connection with modern copper mining, smelting, and refining. The copper ores require a preliminary process of preparation for the subsequent process of roasting, during which the materials are reduced to a condition of extreme dryness in connection with which a considerable amount of dust is produced with more or less health-injurious consequences to the employees. In all of the subsequent processes of roasting, whether in lump or in pulverized form, or in the calcining and the smelting itself, irrespective of the type of the furnace, a considerable amount of dust exposure is inevitable, but since most of the operations are carried on in the open air the health hazards are materially reduced. The introduction of mechanical methods of charging the furnaces and the inclosure of many of the most serious dust-producing operations have during recent years improved working conditions to a measurable degree. There are also reasons for believing that the accident hazards have been reduced, for according to the report of the Bureau of Mines for the year 1915, the fatality rate at ore mills was 1.62, and at smelters 1.21 per thousand employees, which, considering the inherent dangers of the industry, can not be considered excessive.

A descriptive account of the machinery generally in use for rock crushing and ore milling would unduly enlarge the present discussion and be more or less unintelligible without the use of illustrations. Thus far a systematic and well-considered effort has not been made to provide such machinery as far as may be practicable with dust-arresting devices, or to provide otherwise for the more effective protection of the workmen against the risk of dust inhalation which in connection with certain processes attains to most serious proportions. Fortunately from a sanitary point of view much of the labor employed is casual or intermittent, so that distinctly health-injurious effects are less frequently observed than would be the case if continuous employment with considerable dust exposure were prolonged over a period of years. The best scientific account of the diseases of men employed in ore reduction, smelting, and refining is by O. Saeger, of the Friedrichshütte, Upper Silesia (Jena, 1895), following a more extended discussion of accident liability, the effects of severe labor, the health-injurious consequence of heat exposure, contaminated air, intense light, etc. The dust problem is briefly reviewed with reference to its mechanical and chemical characteristics. The latter are of special importance in metallic dust, where lead, arsenic, etc., may prove more immediately injurious than the consequence of dust inhalation in general.

The injurious effect of the finely comminuted dust is conceded without special reference to the metallic content, which, according to its nature, may or may not be of special importance. Modern smelting processes have a decided tendency toward a reduction in the metallic content of the fumes and gases which, in a measure at least, serve the purposes of dust dissemination. Saeger is of the opinion that the mechanical properties of the dust are of greater importance than the dust considered in its chemical aspects, and he refers to the statistics of the miners' union of Upper Silesia for the period 1889–1892, according to which the average percentage of sickness was 47.4 per annum, and the proportion attributable to diseases of the respiratory organs was 7.4. The distribution of this morbidity was as follows: Acute diseases of the lungs and larynx, 7 per cent; chronic diseases of the lungs and larynx, 1.1 per cent; pneumonia, 1.2 per cent; tuberculosis, 0.36 per cent; and other diseases of the respiratory organs, 0.34 per cent. These statistics do not indicate exceptionally serious conditions, but it should be considered that they have reference to persons employed in connection with ore reduction, smelting, and refining in the aggregate and not specifically with any of the more injurious subdivisions, such as work in the rock samplers or at the crushers, grinders, etc. In the absence of trustworthy statistical information the conclusions must therefore be rather general and in conformity to the closely related health-injurious processes in the general mining and stone industries; in other words, the dust hazard in connection with certain preliminary processes in ore dressing, sampling, smelting, and refining is without question of serious sanitary importance, demanding decidedly more qualified consideration than it has heretofore received.

No statistics are available to prove that pulmonary tuberculosis is excessively common among men employed in smelting and refining. The practical problem concerns the control of metallurgical smoke, which consists of three distinct substances—gases, the flue dust, and the fume. Of these three it is only the flue dust that is of serious importance, consisting of small particles of the different ores, fluxes, or fuel. According to an extended account by Charles H. Fulton, in Bulletin 84 of the Bureau of Mines, "the gases, on account of their high velocity entrain these fine particles and when the velocity is reduced in the dust chambers the particles settle. The amount of flue dust made in different smelting operations varies greatly, depending upon such factors as design of furnace, fineness or coarseness of the ore charge, blast pressure or draft employed, and working condition of the furnace. Estimated on the basis of the tonnage of charge that is smelted, it may range from a fraction of 1 per cent up to 10 per cent of the weight of the furnace charge. Thus, in copper blast-furnace smelting at the Copper Queen mine in Arizona, 1 ton of flue dust was produced for every 17 tons of charge, or 5.6 per cent." According to the same authority, "flue dust varies in size from 0.25-inch to 0.125-inch particles of the lighter materials down to an extremely fine dust resembling impalpable powder." The recovery of this dust in modern metallurgical practice, on account of its metallic content, has attained to considerable economic importance; but it is technically difficult to give separate consideration to flue dust as distinct from fume. The latter, according to Fulton, "consists of the volatile constituents of the ore charge which pass off in the form of vapor with the gases from the furnaces and then sublime into minute solid particles in the cooler part of the flues." He explains further that "in examining the dust chambers and the flue system of a smelting plant, it will be noted that a fine gray-white impalpable powder is deposited on the walls, roof, and the floor of the flues near the stack end of the flue system, the amount being greatest at the stack and diminishing as the furnace is approached. In certain sections of the flues and chambers this fume is mixed with the fine flue dust." Since the harmful constituents of smelter smoke generally are (1) sulphur dioxide gas, (2) sulphuric acid formed from sulphur trioxide generated in the furnaces, (3) fume or fine solid particles containing lead and arsenic compounds and acid sulphates, it is self-evident that the hygiene of smelting and refining is of extreme complexity, practically precluding general conclusions in the absence of an extended scientific inquiry at the present time. Sufficient evidence, however, is available to sustain the conclusion that employment in the so-called bag houses is distinctly injurious to health, particularly in connection with the work necessary in the shaking of the bags. According to H. H. Alexander, in an address before the American Institute of Mining Engineers, on the silver-lead smelting practice at the Globe Smelting & Refining Co., Denver, Colo., "in dislodging the adhering fume from the bags handshaking, when done properly, gives the best results, but it is a slow and disagreeable task, and is being replaced by various mechanical shakers. This mechanical shaking is accomplished by striking the inflated bag lengthwise, quickly jerking the deflated bag up and down, swinging back and forth, or a combination of the motions. Another method is to reverse the flow of the gas through the bags by means of an individual fan or by a second connection between each compartment and the suction side of the main fan." Such methods of bag filtration have been found quite satisfactory in extended experience and a considerable amount of dust hazard has been eliminated. The number of men employed in these operations is very small, so that a trustworthy average exposure is hardly obtainable.

The most hazardous work is in connection with employment in the arsenic recovery house, but there is no evidence to prove that the work predisposes to pulmonary tuberculosis.

Since most of the larger smelting plants have been thoroughly reconstructed during recent years, many improvements have been introduced with substantial benefits to the employees. The public aspects of the smelter-fume question have also directed attention to the urgency of fume-dust controlling devices, but, as stated in the report of the Selby Smelter Commission,[1] the normal diffusion of sulphur dioxide is not distinctly injurious to health or productive of disturbing physiological effects upon the lining of the mucous membrane of the throat and lungs of human beings and domestic animals. Under more primitive methods of smelting practice, such as in former years prevailed at Butte, Mont., deaths were frequently caused by the dissemination of sulphur and arsenic fumes into the general atmosphere, but modern methods of fume prevention and control have practically eliminated this risk. Conversely, the changes have been of benefit to employees in the general smelting industry, and mention also should be made of the fact that smoke helmets are employed to an increasing extent for protective purposes, and quite generally in extremely specialized occupations with exposure to the liability of arsenical, lead, and other forms of metallic poisoning. Such investigations as have been made, chiefly by Dr. Alice Hamilton,[2] indicate that the labor force at smelting and refining plants is of an exceptionally shifting nature and at best less than 30 per cent of the force remain in their employment as long as one year. This condition, on the one hand, tends to increase the liability to lead and other forms of metallic poisoning on account of ignorance or indifference to the risk incurred, while on the other hand there is a diminished liability to chronic forms of lung disease, chiefly pulmonary tuberculosis, because of insufficient length of exposure to the injurious effects of mineral and metallic dust. The safety precautions employed are chiefly with regard to the liability to lead poisoning, but they have a direct bearing also upon the reduction in the general liability to more or less serious dust exposure.

The relative importance of dust exposure at different smelting plants naturally varies according to the nature of the product. At a representative smelting plant on the Pacific coast, out of 231 men employed in smelting, 55 were employed in sampling, 17 in ore crushing, and 3 at bag-house labor. Referring to conditions of employment at a typical mill operated under earlier and more primitive conditions, William Winthrop Betts, M. D., of Salt Lake City, Utah, in a communication to the Journal of the American Medical Association (Jan. 13, 1900), directs attention to the fact that in consequence of the increased use of the cyanide process, ore-reduction methods have resulted in a more finely comminuted dust, with a material increase in the mortality rate of the employees. According to Dr. Betts, "Whether we call the cases fibroid phthisis, chronic interstitial pneumonia, stonecutters' phthisis, miners' consumption, or chalicosis, depending on the character and amount of foreign matter, or classify them under the generic name of pneumoconiosis, makes but little difference. All convey to our minds a pathologic process with a clinical history the exact nature of which depends largely on the stage in which the case is found by the pathologist." It is explained by Dr. Betts that at the Delamar mill the ores, which are a gold-bearing quartzite, are crushed, dried, and ground into a fine powder in what is known as the Griffin mill, conveyed to bins, and thence through chutes to cars which are wheeled to the tanks. In and about the mill the air is filled with an impalpable dust and in portions of the mill it is so dense that one can not be recognized a few feet away.

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[1] Report of Selby Smelter Commission, by J. A. Holmes, Edward C. Franklin, and Ralph A Gould, with accompanying papers. Bulletin 98, Bureau of Mines, Washington, 1915.

[2] In this connection see, "Lead Poisoning in the Smelting and Refining of Lead," by Alice Hamilton, M. A., M. D.; U. S. Bureau of Labor Statistics Bulletin, No. 141, Washington, Feb. 17, 1914.

In continuation it is said that—

> The mill has been in operation since September, 1894, employing about 40 men, the capacity being increased from time to time until about 60 men are now being employed. It is stated that most of the men who worked in the mill from seven to nine months previous to January, 1898, are dead and the others are sick. A review of the cases as compared by the employees to March 1, 1899, gives 166 deaths. Since then to my personal knowledge three have died in St. George. A later statement by a gentleman who has the disease himself, and is the editor of a Nevada paper, puts it at 200. Dr. Mayo, who was the company's physician from January, 1895, till a few months ago, and to whom I am indebted for much valuable information, states that only 38 have come to his knowledge. This I am sure is too low, and, while 200 is an exaggeration, I believe an average of these figures nearer correct, as almost every town in Nevada and southern Utah has had its victim, for it is a fact that neither the company nor the men realized their danger until the deaths began to occur. My attention was directed to these facts while at St. George, as quite a number of the young men were employed in the Delamar mill, 11 of whom have died within the past year. A number of others are suffering from the disease. After interviewing the attending physicians and the unfortunate families, I have been able to gather much of interest concerning the cases.

The investigations of Dr. Betts are among the most important ever made in this country, and therefore are deserving of much more extended consideration than has heretofore been accorded them, regardless of the material improvements in methods of management during the intervening period of time. He is of the opinion that many of the men suffer serious injury to their lungs, but return to their distant homes, where "many have died and others must, as the disease involves lesions which do not admit of recovery, and sooner or later prove fatal." He presents the details, of what may be considered a typical case, of a foreman of carpenters who for 27 months had been exposed to the risk of dust inhalation, but who worked 18 months before suffering any inconvenience, although the pathologic process had undoubtedly been established for some time. According to Dr. Betts, he—

> First noticed shortness of breath, loss of appetite, fatigue on slight exertion, and emaciation. The cough and expectoration were slight for months. He has now been in the city for about a year. The pathologic process continues and his symptoms do not improve, though from present indications he will live some months. His clinical history and physical examination reveal a condition typical in fibroid phthisis, and in marked contrast to the poor fellows who after three months' exposure died within a year. Thus we have all grades, as will be shown later, depending on the general constitution and natural resisting power of the men, also largely on the amount of foreign matter inhaled. The mucous and alveolar cells are the normal scavengers of the lungs and are capable of protecting the organ in a measure, but when the dust is excessive the scavengers are overworked and break down, so to speak, leaving the lungs exposed to just what occurs in these cases.

This case may be considered fairly typical of the health-injurious consequences in ore dressing and sampling plants, where sanitary and safety precautions are neglected. According to Dr. Betts—

> Every man who works in the mills from two to three weeks is subject to attacks of acute bronchitis, which is due not only to the irritating effects of the dust, but to his apparent inability to resist slight exposure. The mucous membranes of the nose, throat, and conjunctiva are all subject to acute inflammations. The bronchitis is followed by a soreness along the course of the trachea and bronchial tubes, usually more marked on the right. After coughing has continued for a time there will be soreness in the region of the stomach and loss of appetite. There is loss of weight and shortness of breath, the respirations running as high as 38 to 42 per minute on the slightest exertion. As the weeks pass the loss of weight continues. The respiration does not improve, the patient suffers a general malaise and soon finds it impossible to get about, and by the time he is confined to his room has lost from 30 to 60 pounds in weight. The features are drawn and eyes sunken. The pulse ranges from 90 to 120, and is weak and intermittent. Patients are restless, anxious, and apprehensive of results; they do not sleep well and are subject to hideous dreams. As the disease becomes more marked and in its later stages, the temperature may rise to 102 or 104, though a high temperature is not always present. There is a characteristic odor of the breath at all times, probably due to the peculiar odor of the silicious dust modified by the cyanide odors about the mill, which permeate the clothing and surroundings of the patient. There is no arsenic, as has been stated.

Investigations of this kind involve much labor and serious thought, but they constitute most valuable contributions to the science of industrial hygiene. Dr. Betts sent out special history blanks to all the men whom he could reach, who had worked in the Delamar mill 30 days and over, from the date of commencement until September, 1899. The average number of men employed was only 50, but the change in the personnel working 30 days or over was about 50 each, and in some instances many times more. On account of the unusual labor turnover the actual number of men exposed to the risk of lung injury in consequence of dust exposure during the five-year period was about 1,000. A large number of these were found "to have chronic interstitial pneumonia," and about 100 deaths were ascertained to have occurred, indicating an exceedingly high mortality rate. Thirty cases were tabulated in detail by Dr. Betts as follows, including, most fortunately, observations regarding special processes and a tabulated statement of details of permanent value in the study of the subject:

TABLE 169.—HISTORY OF 30 CASES OF DEATH OF EMPLOYEES OF SMELTING MILLS.

Name and address.	Age.	Height.	Weight.	Commenced work.	Stopped work.	Time worked.	Time to death.	Whole time.
		Ft. In.	*Lbs.*			*Mos.*	*Mos.*	*Mos.*
D. A. A., St. George, Utah, married.	38	5– 7	175	Mar., 1897	Feb., 1898	12	10	22
G. A. L., St. George, Utah, married.	33	5–10	165	May, 1897	Dec., 1897	8	3	11
O. L., St. George, Utah, married.	22	6– 0	175	Aug., 1896	Feb., 1898	16	11	27
F. C., St. George, Utah, married..	35	6– 1	180	May, 1896	June, 1899	(1)	1	37
L. C., St. George, Utah, single....	20	5–10	170	Oct., 1895	Sept., 1897	[2] 23	6	29
G. W. M., St. George, Utah, married.	38	5– 9	150	Mar., 1896	Feb., 1898	19	2	21
H. M., St. George, Utah, married.	28	5– 7	140	Dec., 1895 to Mar., 1897.	Sept., 1897	[3] 9	19	28
J. F., St. George, Utah, married..	28	5– 8	160	Apr., 1896	June, 1896	3	7	10
M. C., St. George, Utah, single...	24	5–10	170	Sept., 1896	Dec., 1896	3	12	15
L. B., St. George, Utah, single...	27	5–10	165	Jan., 1896	Dec., 1898	23	2	25
R. L., Beaver, Utah, single......	24	5– 7	160	Oct., 1897	June, 1898	9	4	13
T. L., Pangistch, Utah, married..	28	5–11	155	June, 1896	Apr., 1897	15	3	18
J. H. L., Pangistch, Utah, married.	40	5– 6	165	1898.......	1898.......	5	7	12
J. H., Delamar, Nev., single......	40	5– 9	140	Oct., 1895	Oct., 1897	24	1	25
Wm. C., Delamar, Nev., single...	39	5– 5	135	Nov., 1896	Dec., 1897	12	1	13
P. T., Baltimore, Md............	23	5– 4	165	Nov., 1897	Oct., 1898	11	3	14
A. W., Columbus, Ohio, single...	24	5– 8	140	July, 1896	Aug., 1898	[3] 25	3	28
J. H., Hillsboro, Ohio, single.....	27	6– 0	210	May, 1895	Aug., 1898	[3] 10	12	39
A. S., Fillmore, Utah, single.....	22	5– 9	155	Apr., 1897	Mar., 1898	12	1	13
J. C., Oregon, single..............	35	5– 6	150	Aug., 1896	Sept., 1897	12	14	26
M. F., unknown, single..........	35	5– 7	150	Jan., 1896	Apr., 1897	14	18	34
J. McC., unknown, single........	27	5– 7	157	Jan., 1896	July, 1896	7	5	12
Chs. F., Gunnison, Utah, married.	36	5– 7	165	Mar., 1896	Sept., 1898	18	12	30
R. H., Masonvally, Nev., married.	38	5– 7	155	1896.......	1898.......	22	11	33
O. N. W., St. George, Utah, married.	43	6– 1	175	Sept., 1894	June, 1897	[3] 30	12	55
E. S., Richfield, Utah, married..	33	6– 2	226	Aug., 1895	Nov., 1898	[3] 19	10	48
A. W. H., Annabelle, Utah, single.	31	5– 8	155	Mar., 1896	July, 1896	4	13	17
J. A. B., Paragonah, Utah, married.	27	6– 0	165	Aug., 1895	June, 1898	[3] 12	15	48
R. P., Colorado, married.........	35	5– 9	145	Aug., 1897	Jan., 1898	6	10	16
F. C., Arizona, married..........	38	5– 6	150	June, 1897	Feb., 1898	8	6	14
General average............	30	5–8½	170			14	10	29

[1] Thirteen months in mill; 9 months night foreman, remainder in mill.
[2] Intermittent; 18 months actual time.
[3] Intermittent.

It will be seen by this report [as shown in Table 169] that all were comparatively young men, from 20 to 40 years old, with the exception of O. N. W., who was 43. All were fine specimens of physical vigor, with no unfavorable family histories, and none had acquired tuberculosis nor any other lung trouble. It will also be noted that the time of employment extended over a period of 3 months in the case of J. F., who survived 7 months after leaving the mill, to 25 months in the case of A. W., who survived but 3 months. The average time of employment, however, was 14 months, and the average time survived, 10 months. The average time from entering the mill to the termination of the pathologic process was 29 months.

The employment was not continuous in all cases. In some instances there would be a lay off of several months, though I was unable to secure exact time. I have designated such as intermittent and given actual time worked. O. N. W. was not, properly speaking, a mill employee, but a carpenter, who originally worked on the construction of the mill, and does not figure in these statistics. He had been employed from time to time in and about the mill on repairs and improvements, thus coming in contact with the same influences as the regular operatives. He survived 4 years and 9 months. In three cases the weights were taken a few days before death. D. A. A. dropped from 175 to 120 pounds, C. F. from 165 to 110, and H. M. from 140 to 80.

The capacity of the Delamar mill is the reduction of 300 tons of ore every 24 hours. The men employed in this process are divided into shifts of eight hours each. Among the 30 cases reported are the members of what I choose to call the Frome shift, as C. F., of Gunnison, who died September 22, 1899, was the last survivor of one of the groups of 18 who worked together long enough at one time between March, 1896, and September, 1898, to claim the personnel of a shift. I mention this as an interesting fact and to further impress the necessity of reforming the hygienic conditions in this line of work.

In amplification several autopsy records are included, of which the two following may be considered typical:

F. C. of St. George.—After the usual preliminaries the sternum was disarticulated from the clavicle, and it, with the cartilaginous ends of the ribs, removed. The inferior surface was adherent to what was at first supposed to be the pleura. After a careful dissection a congested serous membrane was revealed, extending from the sternoclavicular articulation to the diaphragm and well under the ends of the ribs to the right. After further dissection the right lobe of the lung came into view. On the left the adhesions seemed firmer and extended well down some 4 inches. During this dissection a slight puncture was made in the surface, followed by the escape of gas accompanied by bubbles of fluid. This relieved the pressure, and it became apparent that we had an enlarged pericardium to deal with—or pneumopericardium. The adhesions could nowhere be separated with the hand—in fact, they were so strong that it was only after a careful dissection from the diaphragm and spinal column and laterally and posteriorly from lung tissue that the sac could be removed. An effort was made to remove it intact, but most of the fluid escaped, and was of a serous nature, slightly tinged with blood; its size can be imagined from the measurements, 9 inches long and 17 in circumference.

On splitting up and inverting the pericardium the cardial surface was found to be greatly roughened, having much the appearance of tripe. While the membrane was thickened, the heart itself had much the same appearance, the surface being rougher at the base than at the apex. The whole organ was enlarged, flabby, and dilated; the valves were in a fairly normal condition so far as their anatomic relations were concerned.

The anatomic relations of the arch of the aorta and large vessels to the mediastinum, as well as the trachea and bronchi, were entirely obliterated and so matted together that dissection was not attempted. The vessels and bronchi were severed and the lungs removed with little further difficulty, though there were local areas of adhesions which could mostly be separated with the hands. The general appearance was that of congestion, the surface to the eye was fairly smooth, though to the touch nodular and hard, surface generally pigmented, which with the congestion gave a dark color, and the impression that the patient might have died from pneumonia. The edge of the superior, middle, and inferior lobes of the right lung were very hard, though the whole lung seemed firm to the touch. In cutting into the lung there was considerable resistance, made more apparent as local areas of cirrhotic tissue were encountered. The cut surface was reddish brown and extensively pigmented. Between the densely cirrhotic areas the lung was infiltrated with a mucopurulent secretion, which, on the slightest pressure, bathed the surface in a reddish-gray fluid. The appearance after a fresh incision was that of mottled hepatization of pneumonia, i. e., a mixture of the gray and red. The left lung was of the same general character except the lower half of the superior lobes, which was the only portion of the lung apparently being used at the time of death, and that was far from normal. A number of tracheal and bronchial glands from the size of a hazelnut to that of a large olive were removed; these, on section, were slate-gray in color.

O. N. W. of St. George.—There was emaciation; ribs prominent. The sternum, with the cartilage ends of the ribs, was removed. The sternoclavicular articulation was ossified. Adhesions were firm to the pleura and pericardium, the latter adherent to diaphragm; also posteriorly, and slightly so to the left. Bands of adhesion also bound down the aorta and large vessels. The anterior mediastinum was obliterated. The pericardium was slightly thickened through its cardial surface, but smooth and normal in appearance. The heart generally was hypertrophied, otherwise normal. On passing the hand over the lung, slight resistance was met by bands of adhesions, laterally and posteriorly, which, however, were not general and could be easily separated. To the touch the left lung was firm and hard, more that of well-developed muscle covered with dense fascia. In grasping the lobe between the thumb and fingers and using all the force possible approximation was very slight, much the same resistance that would be met in grasping the muscles of the thigh in a similar manner. An incision through the inferior lobe met with considerable resistance and revealed dense fibrous tissue, to the touch a shot-like granular surface and deeply pigmented. The serous coat was dense and one-quarter of an inch thick, gradually becoming thinner toward the apex of the superior lobe. The lung, while cirrhotic throughout, was less dense at the apex, though it was evident it had not been used for some time. As we lifted the right one from the pleural cavity its appearance was that of a single lobe. The adhesions between the inferior and middle lobe were complete, the surface perfectly smooth, only the suggestion of a line remaining. Between the middle and superior lobe there was a slight separation at the very tip, otherwise adherence. A careful examination was made and the fibrous process was found well developed and extensive, the lower border of the inferior and middle lobes being the most cirrhotic. The cut surface was reddish-brown, deeply pigmented and bathed in a mucopurulent secretion, and the same mottled hepatization as in the previous case. The upper half of the inferior lobe and one or two areas near the apex had apparently been sustaining the patient previous to the acute inflammation, which had been present for about a week. All portions of the right lung capable of action were undergoing active pneumonia, with the accompanying characteristics. As in the previous case the tracheal and bronchial glands were enlarged. In both cases a careful search was made for cavities, but none were found. The mucous membrane of the large bronchi and trachea were in a state of chronic inflammation. Owing to the great prejudice and that there had been no symptoms pointing to disease of other organs, the case was not examined further.

In conclusion, the following observations are of much practical importance, especially as regards the actual silicate dust content of the lungs, ascertained in one case to be equivalent to 1.43 ounces, or about 3.38 cubic inches:

In the acute stages of the disease the diagnosis becomes important as the condition has been mistaken for typhoid fever, typhoid pneumonia, acute miliary tuberculosis, and bilious remittent fever and tuberculosis. While pneumoconiosis is the generic name given to the various affections of the lungs produced by the inhalation of dust-like particles, chalicosis pulmonum is given to the pulmonary changes induced by the inhalation of stone dust. Niemeyer, Flint, Osler, and others agree that the irritation from dust lights up a bronchitis and is conveyed through the lymph spaces and lymph vessels into the interlobular and perilobular connective tissue; and some of the particles reach the bronchial glands. The chemical examination of the lung shows the presence of silica, 2.8 per cent, in the lung tissue and 3.8 per cent in the glands. There is a great disposition to the formation of nodules and diffused masses of fibrous tissue. The cases are, therefore, more properly regarded as chronic interstitial pneumonia, which consists in the gradual substitution, to a greater or less extent, of connective tissue for normal lung, by the gradual process of organization of the fibrous plugs in the air-cells, while the alveolar wall becomes greatly thickened by the new growth, and the whole lung may undergo a fibrous transformation.

In addition to the foregoing, Dr. Betts makes the following recommendations concerning possible methods of prevention:

Among the cases coming under our observation there are none where "an ounce of prevention is worth a pound of cure" more emphatically applies than in the diseases induced by the inhalation of irritating dust. No one can study the industrial hygiene and carefully note the relations of occupation to life and health without fully recognizing that from the gentleman of leisure to the mechanical operative, the soldier, and millhand, all have their dangers incident to the various occupations; but it should not follow that no effort should be made to minimize them. I believe it is our duty as scientific physicians not only to point out the danger from contagion, and to render innocuous the germs lurking in our food and water supply, but also to call attention to the causes of disease induced by the industrial occupations, suggest proper sanitary and hygienic measures, and force, by our teachings, a wholesome regard for the comfort, health, and life of the employees, thus reducing the dangers to a minimum. I do not believe any organization, however influential, should presume to dictate to the medical profession or embarrass the physician in his work; much less endanger the health and life of men who are lured by the wages offered—$2 to $5 a day—into what may prove a death trap, and feel they have discharged their obligations to the men, their families, and the public by producing revenues for a "soulless" corporation, regardless of the sacrifice of human life. Notwithstanding the obstruction and criticism I have encountered in the preparation of this paper, no man nor association of men is on trial. This is one of the cases in which truth is stranger than fiction, and I have simply stated facts. If I have succeeded in attracting the attention of the profession and through it the public to the necessity of reform in the field of so-called preventive medicine, I will feel repaid for my time and labor.

SOME GENERAL OBSERVATIONS AND CONCLUSIONS.

The problem under consideration is one of immense magnitude and unusual complexity. Dusty operations are so general and practically unavoidable in all the principal industries, and even in minor occupational activities, that a precise line of demarcation between injurious and noninjurious processes on account of the dust hazard can not be drawn, even on the basis of a thoroughly scientific investigation. The practical importance of the subject, however, is clearly brought out by every qualified inquiry in this country and abroad. Even in coal mining, where the hazard of coal-dust inhalation is apparently of minor significance as regards the predisposition of mine workers to tuberculous and nontuberculous respiratory diseases, modern practices of reducing the calamity hazard, or the liability to disastrous explosions by means of so-called rock dusting, result in occupational dangers which, under given conditions, may reach the proportions of serious menaces to health and life.

According to a discussion of the prevention of coal-dust explosions by watering, or the use of rock dust, in the Coal Age of August 11, 1917, "In the United States rock dusting on a large scale was first tried in a Colorado mine, where sprinkling had caused roof falls. The application of dry adobe dust began in March, 1911, and has been continued to date." Limestone dust is extensively used in the Pittsburgh district, although the method has not gone beyond the experimental stage. It is said further in the article referred to that "objection has been made to using rock dust on account of alleged danger to miners' lungs. Pulverized shale dust has been shown to be noninjurious by British commissions which have particularly investigated this point. Dust containing free silica or sharp particles of any sort is likely to be injurious. Microscopic examination is a quick method of detecting the presence of sharp points or edges and the likelihood of danger from this source." Much more, however, is required than a superficial microscopical examination. As conclusively shown by the South African experience, the silica dust hazard is in almost exact proportion to the minuteness of the dust particles. Careful supervision of rock dusting in mines is, therefore, absolutely necessary and of the greatest importance.

Practically conclusive descriptive accounts of industrial processes are essential to a full understanding of the conditions which give rise to dust hazards in industry. As typical of modern methods of investigation in this direction, though not primarily for the purpose of ascertaining conditions injurious to health and life, is Technical Paper No. 155, of the United States Bureau of Mines, on "Gypsum Products, Their Preparation and Uses," by R. W. Stone, of the United States Geological Survey. This account includes a full description of mining, crushing, drying, grinding, calcining, regrinding, mixing, storage, etc. Such descriptive accounts are, fortunately, being made to an increasing extent for the more important branches of the mining and metallurgical industries. The solution of the dust problem, in so far as it permits of a solution at all, must necessarily depend very largely upon a thorough understanding of the technical industrial processes which give rise to health-injurious conditions reflected in the statistical evidence of an excessive incidence of tuberculous and nontuberculous respiratory diseases.

From a medical point of view further progress is essential in the direction of greater accuracy and scientific conclusiveness as regards the classification of pulmonary tuberculosis as well as of nontuberculous lung diseases. An important recent contribution to this aspect of the problem, by Walter L. Rathbun, of the Municipal Sanatorium, Otisville, N. Y., has been made available through The American Review of Tuberculosis (March, 1917). Reference may also be made to a strictly scientific discussion of the important question of "Respiratory Exchange, with a Description of a Respiration Apparatus for Clinical Use," by Benedict and Tompkins, contributed to the Boston Medical and Surgical Journal of June 15, 22, and 29, 1916. There could be no more erroneous view than that all that needs be known concerning the physiology and pathology of the respiratory function is fully understood at the present time. Mention need only be made of such an important discussion as that on "The Effect of Changes in Atmospheric Conditions upon the Upper Respiratory Tract," by Drs. James Alexander Miller and Gerhard Hutchison Cocks, contributed to the "Transactions of the American Climatological and Clinical Association," in 1915.

This discussion clearly emphasizes the importance of changes of temperature and abnormal temperature conditions, which frequently coincide with abnormal dust exposure in the mineral and metallurgical industries. Mr. Edwin M. Chance, the chief chemist of the Philadelphia & Reading Coal & Iron Co., contributed an important practical discussion on "The Examination and Physiological Action of Pathogenic Mine Atmospheres, with Considerations Governing the Use of Breathing Apparatus," to the Journal of the Franklin Institute, for November, 1911, which has an indirect bearing upon the larger question of health-injurious results of underground employment in consequence of continuous exposure to abnormal atmospheric conditions. It is regrettable that an exceptionally promising investigation on "Pulmonary Anthracosis," by Oskar Klotz, of the pathological laboratories of the University of Pittsburgh, made in connection with the smoke investigations of the Mellon Institute of Industrial Research, should not have been continued and amplified by the required additional data based upon a larger number of autopsy records. This admirable study, however, includes some very suggestive anatomical considerations, the ascertainment of the distribution of pigment beneath the visceral pleura, the occurrence of interstitial pulmonary anthracosis, and the modification of anthracotic deposits by other factors. There have been few more useful American contributions than this to the strictly scientific study of lung diseases in their relation to the continuous inhalation of health-injurious dusts and inorganic atmospheric pollution. The discussion concludes with some observations on the quantitative estimation of carbon in the lungs, limited, unfortunately, to nine cases. Among the conclusions advanced is the statement that pulmonary anthracosis, as clearly differentiated from coal miners' anthracosis, is distinctly an urban disease and is proportionate to the smoke content of the air, and that carbon deposits, by inducing fibrosis, tend to encapsulate chronic tuberculous foci, and therefore afford a relative measure of protection against the further development of incipient tuberculosis, which probably accounts for the lower proportionate mortality from the disease among coal miners as well as among the population of coal mining communities or localities subject to a large amount of atmospheric (carbon) pollution.

These observations are referred to on this occasion merely as promising indications of research efforts of a high order of practical importance to employers and employees in trades and occupations subject to an exceptional degree of health-injurious exposure to industrial dusts. It requires no argument to reemphasize the point of view that as a general rule no single factor in industry is directly responsible for even the larger portion of the excess in the mortality from tuberculous or nontuberculous respiratory diseases, although the removal or control of the dust hazard will often bring about a material reduction in the death rate. The dust hazard is but one of many factors and conditions in modern industry more or less detrimental to health and life, and genuine and lasting progress in this direction must therefore rest upon rational considerations of industrial hygiene, as clearly set forth in an address on the "Standardization of Working Essentials," by Miss Lillian Erskine, investigator of occupational diseases of the New Jersey Department of Labor, contributed to the proceedings of the American Academy of Political and Social Science in 1917. This address includes an extended and most useful reference to the problem of dust removal, it being stated in part that—

> When it is remembered that at each breath some 60 cubic inches of dust-laden air may be inhaled by a worker, the ultimate injury possible to the 20 square feet of surface of the 500,000,000 air cells of his lungs becomes apparent. In the case of buffers, grinders, and polishers (before the days of mechanical exhaust protection), the tuberculosis mortality of the group exceeded 60 per cent, in contrast to the normal 14 per cent for the general registration area. Printers, subjected to lead dust and fume, show a consumption mortality in the neighborhood of 70 per cent. Almost as high are the records of potters exposed to flint dust, and of mill workers subjected to clouds of irritating wood dusts.
>
> Aside, however, from questions of health, a dusty workroom inevitably lowers standards of shop discipline and output; induces chronic intemperance (due to thirst engendered by congestion of the mucous membrane of the throat), and a general sense of physical malaise and depression; and commonly increases friction in personal relations with the foremen, among those whose normal recuperation from physical and nervous fatigue is made impossible by the unsanitary conditions of their working environment. While the direct financial loss involved in the waste of a majority of dusts and fumes in the workrooms is not of serious moment to the management, the indirect losses above noted justify the most rigid precautions for their control. The secret of successful mechanical exhaust removal of dust and fume from working processes lies in its control at the point of origin. While this was once regarded as impractical in many industries, modern engineering experience has solved practically every working problem, whatever be the specific gravity of the dust or fume in question.

Miss Erskine properly directs attention to the harmful results of indefinite and unscientific sanitary requirements, and the misuse of the terms "adequate" and "sufficient" resulting frequently in only a very limited amount of protection, secured at very considerable expense. She points out that—

> The usual and inexpert practice in building a dust-exhaust system, such as is required for buffing, polishing, or grinding wheels, is to proportion the main suction pipe so that at all cross-sectional points it only equals the combined areas of the branch pipes entering the same; while the inlet of the exhauster used on such a system has an area that but equals the combined areas of all the branch pipes used on the system. For example, for twenty-five 4-inch branch pipes the largest diameter of main pipe and exhauster would be 20 inches. A 50-inch exhauster would have an inlet 20 inches in diameter; if it were necessary to get a suction head at each branch pipe sufficiently strong to displace 2 inches of water in a pressure gauge (commonly called a U-shaped tube) it would require an actual velocity of 4,000 linear feet per minute in the branches, and it would be necessary for the exhauster to handle 8,720 cubic feet of air. It would require approximately 16 horsepower to obtain these results.

These observations fully justify Miss Erskine's conclusions that inadequate and unscientific systems of ventilation should no longer be permitted, since standards based upon actual working tests and experience prove conclusively "that efficiency requires for 4-inch pipes a main pipe with, at all its cross-sectional points, an area 20 per cent larger than the combined areas of branch pipes entering the same. The inlet of the exhauster attached to the system must have an area 20 per cent larger than the combined areas of all branch connections on the system. For example, a system having twenty-five 4-inch branch pipes would require an exhauster that has an inlet 22 inches in diameter; and the main pipe connected with this exhauster would taper, in accordance with the location of the branches, from the exhauster to the tail of the system. This kind of system would require a 55-inch exhauster having a main pipe 22 inches in diameter; and to obtain a suction sufficient to displace 2 inches of water in a U-shaped tube, the air in each branch pipe would be obliged to have a velocity of 4,000 linear feet per minute. The exhauster would handle 8,720 cubic feet of air a minute; and the exhauster would take about 12 horsepower to operate it."

Through the adoption of scientific methods of dust removal it is possible to secure a saving of 25 per cent in horsepower, aside from the resulting reduction in, or elimination of, conditions of air pollution detrimental to the health and life of the employees.

In its final analysis the problem of dust control in industry demands obviously both practical and strictly theoretical considerations. There has heretofore been too much reliance upon general practical aspects of dust removal, since, as a matter of everyday experience, the mere mechanical material reduction of the dust hazard in industry almost invariably results in a consequent improvement in the health and longevity of the employees directly concerned. In connection with many highly involved industrial processes the effective control of the dust menace is, however, often subject to exceedingly complex theoretical considerations suggestive of further research in a field which has received inadequate attention on the part of those qualified to render most useful services to the workers engaged in industrial processes indispensable to the needs of mankind.

The most encouraging evidences of an aroused national interest in this important and promising field of industrial research are the occupational disease investigations of the United States Bureau of Labor Statistics and the United States Bureau of Mines. On account of its practical importance emphasis may, therefore, in conclusion, be given to a recent circular of the Bureau of Mines, prepared by Dr. A. J. Lanza, of the United States Public Health Service, and Joseph H. White, of the Bureau of Mines, on "How a miner can avoid some dangerous diseases," and which, with reference to rock dust, emphasizes conclusions generally applicable to the dust problem, as follows:

> Dust is not a disease, but it is the cause of disease. Any hard, sharp rock dust when breathed into the lungs irritates and cuts them, making many small scars. These scars make the lungs less able to perform their proper duty. Besides, because of the constant irritation, the lungs become inflamed, and consumption is liable to develop. Men who breathe hard-rock dust constantly often get consumption. The constant irritation of the lungs weakens them and at the same time gives the seeds of consumption a good chance to grow. The dust breather is also more liable to fall a victim to the careless spitter than the man whose lungs are sound. If he gets pneumonia his chance of recovery is not so good. The dust breather has to fight not only the effects of any lung disease he may get, but also the harmful effects of the hard-rock dust, which is constantly adding to the ravages of the disease.
>
> Working in dust, like exposure, is at times unavoidable, but a great deal, if not most of the dust breathing, is due to carelessness on the part of the miner himself, who does not realize the danger of so doing, or, if he does, is indifferent to it. It is another example of failing to keep up the bars around an open place. In dust breathing, however, cause and effect are not so plain—at least they do not seem so to the miner. But the relation is there just the same. The number of deaths from lung diseases among metal miners is much greater than among coal miners and is probably ten times greater than it ought to be.
>
> What can the miner do to avoid breathing dust? Water drills are being used more and more. In dry drilling with machines it is possible to lay the dust by water lines or by using a squirt gun and water from a bucket, but often men drill with the hole dry rather than

turn on the water, because it spatters on them, or makes the place sloppy. If you are drilling overhead, and the water has to come back on you, wear a rubber hat and boots and, if necessary, a rubber coat. This is a bother, but it is also a bother to observe all the rules of "safety first"—which save lives. A man working where there is much dust should wear a respirator if possible, and see that the respirator is in good condition. Respirators are clumsy and more or less of a nuisance, but it is better to wear one than to have consumption. Do not breathe hard-rock dust day after day, because, if you do, it will disable you in time. Men who can "eat rock dust"—like the men who can "breathe gas"—die young.

These recommendations apply to a large section of the mining population and to men employed in metallurgical industries. In a broader sense, however, all inorganic dust in industrial occupations demands the most effective safeguarding of the employees against unnecessary hazards to health and life. What has thus far been done in this direction has unquestionably resulted in far-reaching benefits to the wage earners.[1] Much more, however, is required if the obviously excessive mortality from tuberculous and nontuberculous lung diseases in the dusty trades is to be materially reduced as a prerequisite for the attainment of a higher standard of labor and life than prevails in this and other countries at the present time.

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[1] See in this connection Bulletin 132, of the United States Bureau of Mines, on Siliceous Dust in Relation to Pulmonary Diseases among Miners in the Joplin District, Missouri. Washington, 1917. Note also the appointment of a special committee on the Scientific Study of Dusty Trades in their Relation to Pulmonary Tuberculosis by the National Association for the Study and Prevention of Tuberculosis.

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THE DUST HAZARD TO HEALTH IN THE STONE INDUSTRY

Dr. Frederick L. Hoffman, Third Vice President and Statistician, The Prudential Insurance Company of America, Newark, N. J.

Mr. Chairman and Members of the National Safety Council: The subject of my address is one to which I have given careful thought for more than twenty years. All of you are mining men but I question if any one of you has visited more mines, and different types of mines regarding the material extracted, in this and other countries than I have. It has been my privilege to visit even such remote mining fields as Newfoundland and Alaska. After I leave here I expect to visit, for several days, the great Homestake mines of South Dakota and other mines in the Black Hills. My interest in mining matters is primarily for reasons of our business of life insurance. The proper rating of mine employes has always been a difficult practical question on account of the wide variation in mining hazards according to the mineral extracted, or the methods of mining followed in the different sections of the country. Our earlier information was chiefly derived from English and continental sources, but it soon became evident that, for reasons of accuracy and equity, our practice should be based, as far as possible, upon the ascertained facts concerning mine experience in this country. The evidence is absolutely conclusive that, as a class, mine employees suffer more seriously from accidents and general diseases than men employed in manufacturing and general mechanical pursuits. For certain groups of mine employees, such, for illustration, as those engaged in underground mining in Southwest Missouri, or in the copper regions of Montana, the mortality from tuberculosis, and even non-tuberculous respiratory diseases, is unquestionably excessive. The immediately contributory factor responsible for this condition is the dust, which is now a much more serious problem than formerly on account of the practically universal use of pneumatic tools. I need not enlarge upon this problem, which is one that I may assume to be thoroughly familiar to all mining men.

INVESTIGATIONS IN JOPLIN DISTRICT

I may also assume that most of you are familiar with the investigations which have been made by the U. S. Bureau of Mines into the subject of siliceous dust in relation to pulmonary diseases among miners in the Joplin district. These investigations by Higgins, Lanza, Laney, and Rice are contributions of the first order to the subject of industrial hygiene in its special application to the mining industry. We have not, however, made the required progress in this country which would make our own investigations comparable to those, for illustration, of the South African Commission on Miner's Phthisis. The urgently required active cooperation of practical men familiar with underground conditions in the mining industry, of men engaged in the practice of medicine among mining men, and of scientific minds of a high order, thoroughly familiar with highly specialized methods of technical research, has not as yet been forthcoming in this country, though the outlook in this respect was never as encouraging as it is to-day.

The use of pneumatic tools in the mining industry is in itself a problem demanding special consideration. The danger to the health of the employees is in almost exact proportion to the continuance of the dust, or as the initial effects of dust inhalation are apparently harmless they generally prove more deadly in the end. Or more specifically, it is chiefly a question of the minuteness of the dust, the most dangerous particles of which are generally ultramicroscopical. It is these dust particles that cause a continuous irritation of the lung tissue and bring about serious lacerations, followed by fibroid processes and ulcerations as a predisposing condition to a subsequent tuberculous infection. Tuberculous germs, of course, are practically everywhere and perhaps not much more common underground than above ground, but they are so much more dangerous in places where the sunlight does not penetrate, and where the viability of the germ is probably more prolonged than in the outside atmosphere. Conformity to sanitary requirements underground is, therefore, of the most importance in mine management if the health of the employees is to be adequately conserved, and particularly so against the risk of tuberculous infection.

PUBLICATIONS OF UNITED STATES GOVERNMENT

Qualified opinion is more or less at variance as to whether or not all mineral dust is injurious to the lungs. In a technical sense this is probably true, but there are important exceptions to the view that all dust inhalation is seriously harmful and a predisposing cause of tuberculosis. Much depends upon the mechanical and chemical properties of the dust inhaled and the conditions under which inhalation takes place. Men otherwise robust and in good health, with their vitality unimpaired, may suffer a much lesser degree of injury than those who have their vital resistance reduced by industrial fatigue, malnutrition, or habits of gross intoxication. As a practical question, our interest at this time should be concentrated upon the dusts that are most harmful, upon the specific occupations that are most affected, and upon the underground conditions that demand the most rigid supervision and control. Siliceous dust is unquestionably the most serious, while the dust of limestone or of cement is probably the least harmful. Much, however, depends upon the nature of the material and the minuteness of the dust inhaled. The quantity and continuity of the inhalation is also a matter of considerable importance. In a recent contribution of mine on the "Mortality from Respiratory Diseases in Dusty Trades," limited to inorganic dusts, and published as Bulletin No. 231 of the U. S. Bureau of Labor Statistics, I have enlarged upon certain aspects of the mining industry, which makes extended consideration unnecessary at the present time. The bulletin can be had on application to the U. S. Commissioner of Labor Statistics, Washington, D. C. The discussion includes all available mortality statistics, derived from insurance or official sources, and amplified by references to technical discussions in mining periodicals, etc. As yet there has not been forthcoming a standard treatise on mine hygiene and sanitation by an American authority based upon carefully ascertained conditions in American mines, mills and smelters, such as is most urgently required in the furtherance of the broader plans and purposes of public health administration, with special reference to labor and industry. Textbooks on mining, as a rule, make only fragmentary reference to health and sanitation, and usually only with reference to either very general or very exceptional conditions, such, for illustration, as the liability to poisoning in quicksilver mines, or to cyanide poisoning in the management of cyanide plants. It is therefore gratifying to meet with an increasing interest on the part of the U. S. Bureau of Mines in the hygienic aspects of the American mining industry, amplified by special investigations on the part of the U. S. Bureau of Labor Statistics, the U. S. Public Health Service, and the Working Conditions Service section of the Department of Labor. A forthcoming publication on "The Health Hazards from the Use of Air Hammer in Cutting Indiana Limestone," by Dr. J. P. Leake, of the U. S. Public Health Service, and two supplementary reports on the "Supposed Physical Effects of the Pneumatic Hammer on Workers in Indiana Limestone," by Dr. David L. Edsall, and "The Effect of the Air Hammer on the Hands of Stonecutters," by Dr. Alice Hamilton, to be issued by the U. S. Public Health Service in bulletin form for general information, may here be referred to as practical indications of an aroused interest in a highly specialized branch of inquiry, which is also receiving the attention of a committee appointed by the National Tuberculosis Association. This committee will concern itself chiefly, at the outset, at least, with the health-injurious effects of employment in the stone industry, limited, however, to the granite and marble quarries of Vermont and the limestone quarries of southern Indiana. The committee, in course of time, however, intends to take up the question of underground mining conditions, and the cement industry, in which the health-injurious effects of dust inhalation are apparently of much less consequence than in underground mining with exposure to the inhalation of siliceous dust.

VIEWPOINT OF EXPERIENCED MINE SUPERINTENDENT

The paper to be read by Mr. Borcherdt, Superintendent of the Bertha Mineral Company, of Virginia, of which copies have been made available preliminary to this meeting, is one of the most useful contributions to the subject under discussion. This paper is the second one by Mr. Borcherdt, who last year made an important contribution to the subject of the abatement of dust in drilling operations by the more effective use of water drills. The paper is so much more important in that it presents the viewpoint of an experienced mine superintendent, and that the supplementary analysis gives the results of a questionnaire sent to some twenty or thirty mining companies throughout the country. If such a service has been performed by a mine superintendent abroad he would have been most highly honored, not only by his profession but by the

Government and the public at large; for there is the utmost urgency for voluntary service of this kind on the part of the layman thoroughly familiar with certain phases of an important question, which can not possibly be within the understanding of government mine officials or members of the medical profession. It is to be hoped that Mr. Borcherdt will continue his investigations in this fruitful field of scientific inquiry and that he will present the results of further investigations at subsequent meetings of this Congress.

The problem of mine dust and miners' mortality is clearly one of increasing economic importance to the mining industry. Every life of an experienced mine employe prematurely shortened represents a serious economic loss. All practical methods of health improvement, or life prolongation, rest, therefore, upon a sound economic as well as social and humanitarian basis. There has recently been issued a final report on Industrial Health and Efficiency, by the Health of Munition Workers Committee of the British Ministry of Munitions, in which there occurs this suggestive observation:

"Sickness due directly or indirectly to the industrial occupation takes various forms and degrees from the passing headache to serious organic disease of fatal issue. The lungs, the heart, the digestive organs, the nervous system, the muscular system—each or all may be affected with results harmful both to industrial efficiency and output, and also to personal health and expectation of life. Moreover it must be remembered that an undue proportion of sickness in any group of workers usually represents among those not actually sick lessened vigour and activity which can not fail to reduce output. Disabling conditions or influences which injure some have a tendency to mark all. Employers and their work-people should therefore have a general appreciation of these injurious conditions if they are to be on the outlook to guard against or mitigate their evil effect."

After enumerating the causes or conditions responsible for sickness occurrence in industry, including among others, excessively long hours of work; cramped and constrained attitudes; prolonged and excessive muscular strain; working in unventilated or insufficiently ventilated shops; imperfect lighting, conducive to eye strain, headache, etc.; and exposure to gases, vapors, poisons, or other irritating substances; reference is made to the dust produced in certain industries and productive of lung disease unless effectively safeguarded against by adequate protective measures. The report concludes with the statement that—

"Though these are a sufficiently formidable list of disabling conditions, or conditions which without proper care and precaution may readily cause disablement, they do not complete the inventory. At least as important as any of these occupational influences, but inseparable from them, is the predisposition to disease arising from the absence of personal hygiene. The necessities of individual health are few and simple, but they are essential. Suitable and sufficient food, fresh air, warmth, moderation. cleanliness in ways and habits of life, the proper inter-relation of work, repose and recreation of mind and body are laws of hygiene, the elements of vital importance for which facilities must be provided if the maximum industrial output of the individual is to be secured and maintained. These matters need consideration by the management just as much as the healthy supervision of the external circumstances of the factory and its technical processes."

UNDERGROUND CONDITIONS IN CALIFORNIA

These observations are strictly applicable to the mining industry. They are best illustrated by the results of a recent inquiry into the occurrence of hookworm in underground mining in California, due largely to sanitary indifference and neglect. If it is true that over 50 per cent. of all the men are infected in certain mines, the economic efficiency of these men must be reduced very considerably, with a consequential financial loss to the mining industry. In some mines which I have visited the underground sanitary conditions are appalling. No cattle above ground would be housed or herded in such a thoroughly indifferent manner. The men are required to eat their meals underground, frequently amidst filthy and contaminated surroundings. The meal itself is only too often wanting in nutriment or otherwise health-promoting qualities. This is an aspect of miners' hygiene which has only of late received consideration. The investigations of the Health of Munition Workers Committee draw attention to the problem of food and canteens just preceding the consideration of the question of sickness and ill health.* The conclusion is advanced by this Committee, which consisted of the foremost British experts on the subject, that—

"There is now an overwhelming body of experience which proves that productive output in regard to quality, amount and speed is largely dependent upon the physical efficiency and health of the worker. In its turn such physical fitness is dependent upon nutrition. The purpose of nutrition is to secure the health, the proper development and growth, the repair and vital energy, of the human body. Food energy is spent in maintaining the tissues of the body and the body heat and in doing work. Nutrition is stimulated by the cooling effect of fresh air, and by bodily exercise, and its needs must be met by a food supply suitable in character and sufficient in amount to meet the expenditure on body heat and work."

In the light of my own investigations, I am absolutely satisfied that the food of miners is frequently unsuitable as regards quality though generally sufficient as to quantity. The conditions under which the food is eaten underground are often, if not generally, entirely unsatisfactory. The food is often in a deteriorated condition, with the result that intestinal or digestive diseases are relatively common. It would therefore seem well worth while for the mining industry to give more thoughtful consideration to this question and provide better facilities for the eating of meals underground, where the leaving of the mine for the meal hour would prove impracticable. Sufficient time for meals should also be allowed, and a full hour would seem a proper period.

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*See in this connection "Standards of the Department of Health and Sanitation" of the United States Shipping Board Emergency Fleet Corporation, 1918, and "Restaurant Facilities for Shipyard Workers," by Frederick S. Crum, also published by the United States Shipping Board Emergency Fleet Corporation, Philadelphia, 1918.

These observations, of course, bear only directly upon the dust problem. Whatever diminishes disease resistance is, however, a contributory factor in the mortality from tuberculosis, and an anaemic miner is unquestionably more susceptible to the disease than one whose blood supply is of the required quality. The same observation applies to the physical examination of mine employees. A fair proportion of the men employed are physically unfit for the exacting, and occasionally exhausting, duties to be performed. Regarding all such conditions as anaemia, possibly associated with diseases of the heart and circulatory system, nervous exhaustion, derangement of special physiological functions, etc , the Health of Munition Workers Committee points out that though not in all cases immediately incapacitating, "they frequently tend to become chronic in nature and far-reaching in effect, and they lead directly to malnutrition and reduction of bodily energy. If allowed to persist they invariably lay the foundations of ill-health and disease in later years." A thorough physical examination, and periodical re-examinations, would eliminate from the mining industry men physically unfit, though by no means unsuitable for other employments. By thus raising the physical standard of mine workers the liability to tuberculous and non-tuberculous lung diseases would of itself be materially reduced regardless of the dust hazards underground.

NEED OF BETTER TEACHING METHODS

There is need of better teaching methods in matters of personal hygiene. The experienced mine worker is generally a man of more than average intelligence, and the success of the first-aid movement has conclusively shown his willingness, if properly approached, to co-operate with the mine owner and the Government. There are no reasons for assuming that he would not be willing to co-operate even more actively in matters concerning his immediate personal physical welfare and his future health and longevity. Cause and effect in chronic lung diseases are unfortunately often remote from each other. Minute particles of dust may be inhaled for years without apparently serious consequences to the health of the individual concerned. All those who are thoroughly familiar with lung fibrosis know of cases where the onset of active symptoms was extremely sudden and where death followed within a comparatively short period of time. At autopsy the condition of the lungs will, however, disclose serious deterioration extending over many years. It is too much to expect in a mine laborer a degree of intelligence in matters of personal habits conducive to good health not met with even among men in professional life. The effective teaching of the principles of the hygiene of the respiratory apparatus, including, for illustration, the dangers of mouth-breathing and the importance of removing obstructions in the nasal passages; the prevention of nasal catarrh; the danger of adenoid growths as well as the more simple rules concerning the prevention and treatment of tuberculosis, is a matter which is yet but very inadequately dealt with in attempts which have been made to improve the health of mine employes by suitable methods of health propaganda.

MECHANICAL CONTROL OF DUST EVIL

After all, however, the main problem is the mechanical control of the dust evil. There can be no serious objection to the compulsory use of the Water Lyner drill subject to certain qualifications in important matters of technical detail. The health of the workmen is of vastly more importance than reckless mine exploitation to the point of positive indifference and apathy in matters of mine sanitation. In a large measure the dust menace can be controlled by a rational adaptation to underground conditions by the use of Water Lyner drills, by better care in the use of pneumatic tools, etc. How this can be done at minimum expense and without serious interference with productive processes has been made clear to us by the impartial investigations from the employers' point of view by Mr. Borcherdt, of the Bertha Mineral Company, of Virginia. Mr. Borcherdt's observations on the proper construction of respirators are of special interest. It is to be hoped that he will continue his inquiries, for more information is urgently required. It is regrettable that thus far the subject should not have attracted the proper attention of the American Museum of Safety, which has adequate facilities for the display of the most useful devices. It might also be suggested that possibly the Bureau of Standards might take up this question and institute an inquiry to determine the type of respirator best adapted to the protection of the employees against different forms of dust. In my own investigations I have frequently met with men who had been using respirators in dusty stopes for a number of years and without serious inconvenience. In many cases, however, the men naturally object to the use of respirators of improper construction and therefore inconvenient, if not entirely unsatisfactory, for practical service. Under certain conditions particularly in small and narrow stopes, the use of respirators remains the only safeguard unless work of this character is to be prohibited by law. There are natural limitations to the use of spraying devices, or humidification, suggestive of further perfections in respirators, thus making them more suitable for the purpose than is generally the case at the present time.

PROBLEM OF FIRST ECONOMIC IMPORTANCE

I trust that I have made myself clear as regards the very practical importance of dust elimination in underground mines as a problem of the first economic importance to the mining industry. Further apathy and indifference are certain to be followed by serious consequences to those responsible for the continuance of conditions largely unnecessary in the light of our present-day understanding of the facts and the methods by which conditions obviously detrimental to life and health can be brought more or less effectively under control. It is not a question of aiming at the ideal, but merely of a deliberate effort to bring about a decidedly more satisfactory state of affairs than exists at the present time. It is therefore to be hoped that, on their own part, mine managers will give this problem more serious concern in the future, and that they will take into account the splendid work which has been done by the mine owners of South Africa in their active cooperation with the Committee on Miners' Phthisis Prevention, and on the part of the Transvaal Chamber of Mines, which includes in its annual reports extended and well considered observations on the health conditions in mines, the miner's phthisis amendment act, the pay of employees attending medical examinations, the work of the prevention committee, the miners' sanatorium, the silicotic employment office, and the silicotic sanatorium, as well as the general work of the Medical Bureau. The Chamber has a standing committee on dust sampling, which, for the year 1917, reports a steady reduction in the number of cases of dry drilling. The Medical Bureau, for the same year reported that the periodical examination of European miners had proceeded systematically, and that the mining companies had agreed that the employee should be paid for the time required on account of the examinations, including the payment of railway fares. Of special interest in this connection is the statement in the report for 1917 as regards the success "in the prevention of pneumonia following the use of Dr. Lister's anti-pneumonia vaccine." It is pointed out that pneumonia was the principal cause of death among natives from tropical sections, but chiefly such as had previously been employed in the mine at the Rand. The Medical Bureau also reported that it had carried out many experiments with devices for the prevention and allaying of dust in mine air, and that, "it also, at the request of the Miners' Phthisis Prevention Committee, made a large number of tests with the Kotze 'Konimeter'—an apparatus designed to collect on a slide the dust particles in a given quantity of air, in such a manner as to enable those particles to be counted under the microscope. In the opinion of the Dust Sampling Committee there is indication that the apparatus, when further developed, will provide a convenient method of rapidly determining the approximate dust condition of the air sampled."

SPLENDID WORK ACCOMPLISHED

It cannot be too strongly urged upon mine managers and all others concerned with the more scientific control of health conditions, especially in underground mining, but also the proper sanitation of mine villages, etc., that they take into consideration the splendid work in this respect which has been done by the mine owners of South Africa, through the Transvaal Chamber of Mines and the Rhodesia Chamber of Mines, which, in 1917, issued its twenty-third annual report, including sickness and mortality returns of considerable value, and some exceedingly interesting observations on the prevention of pneumonia among the native population.

The most important source of information, however, is the general report of the Miners' Phthisis Prevention Committee, issued in 1916, of which it is hoped that some time a reprint may become available through the U. S. Bureau of Mines, as unquestionably one of the most useful contributions to the subject. The more technical aspects of the problem have received fairly extended treatment in the recently issued Mining Engineers' Handbook, by Robert Peele, professor of mining engineering in the

School of Mines of Columbia University. The section on Mine Air, Hygiene, Explosions, and Accidents, is by Mr. George S. Rice, chief mining engineer of the U. S. Bureau of Mines, who has admirably summarized the more essential facts concerning the effects on health of impurities and conditions of mine air; the dangerous qualities of siliceous dust, with observations on remedies, etc., as well as the permissible percentages of impurities, but of only very limited application to the problem under consideration. It may properly be suggested that the Bureau of Mines should concern itself more actively with this important problem as one of the first importance to all mine employes, mine managers, mine owners, and the Government. I thank you.

DISCUSSION

Mr. R. Dawson Hall: Fortunately for the coal industry the dust in the coal mines does not appear to have a very detrimental effect, as far as tuberculosis is concerned. The mortality tables of the United States show that the group "bankers, brokers and officials of companies" has the lowest tuberculosis death rate. Then come the "lumbermen and raftsmen," then "farmers, planters and farm laborers," then "miners and quarrymen." Everyone is ready to concede that the position of the "miners and quarrymen" near the bottom of the list, with fifty-three classifications above them, is due rather to the freedom of coal miners from tuberculosis than to any freedom from that diseases enjoyed by the metal miners or quarrymen who, many of them, work in siliceous dusts and on dry material (*Coal Age*, Aug. 24, 1912). For some reason, the dusts in most coal mines have been found not to be harmful to either horse or man.

Some time ago one of the big coal companies in Colorado endeavored to make an investigation of this matter and find out some of the reasons for it. The chemists of the company inquired into the solubility of the various dusts found in a coal mine, to see what proportion of those dusts were solvent. I am sorry to say that the liquids which they used in dissolving those dusts were such as are not in general to be found in the lungs.

It seems to me that if we are going to try an experiment on solubility we should endeavor to dissolve the dusts in those particular fluids with which they would come in contact in the lungs, and then possibly we may be able to find out when and why the disease they call silicosis is likely to occur. Apparently the miner is more subject to asthma than to tubercular affection. Some people have gone so far as to say that the coal-mine dust gives specific resistance to tuberculosis and that the air of the coal mine is free from tubercular germs. Whether that is true or not, I cannot say. If it is, then probably what tuberculosis exists among coal miners has a domestic and not an industrial origin.

FEW CASES OF HOOK WORMS IN NORTHERN COAL MINES

As regards the hook worm, it is a worm which only develops at temperatures which are higher than those found in most of our coal mines.

U. S. DEPARTMENT OF LABOR
WORKING CONDITIONS SERVICE
GRANT HAMILTON, Director General

PRELIMINARY REPORT
OF
COMMITTEE ON MORTALITY FROM TUBERCULOSIS IN DUSTY TRADES

WASHINGTON
GOVERNMENT PRINTING OFFICE
1919

INTRODUCTION.

This preliminary report of the Committee of the National Tuberculosis Association on the Mortality in Dusty Trades affords students a rare opportunity to gain a real insight into the methods of the committee. It announces the formation of a committee and its program of investigation in a field that has long been recognized as of primary importance in industrial hygiene. The immediate investigations will deal with trades in which inorganic dusts have been found to be harmful to workers—the marble and granite industries and work in quarries. From time to time additional reports will be published giving the progress of the committee's work. The committee consists of the following:

Dr. Frederick L. Hoffman, chairman, third vice president, and statistician, Prudential Insurance Co., Newark, N. J.

Dr. Edward R. Baldwin, Trudeau Sanatorium, Saranac Lake, N. Y.

Dr. Alice Hamilton, expert, Bureau of Labor Statistics, U. S. Department of Labor, Washington, D. C.

Dr. H. R. M. Landis, Henry Phipps Institute, Lombard and Seventh Streets, Philadelphia, Pa.

Dr. A. J. Lanza, chief, Industrial Hygiene and Medicine, Working Conditions Service, U. S. Department of Labor, Washington, D. C.

Dr. O. W. McMichael, Asheville, N. C.

Dr. Alfred Stengel, professor of medicine, Medical School, University of Pennsylvania, Philadelphia, Pa.

The report is published by the Working Conditions Service as part of its work of giving information of scientific studies made to better working conditions. The work of the committee will be of practical assistance to the service.

GRANT HAMILTON,
Director General.

SUMMARY REPORT OF THE COMMITTEE ON THE MORTALITY FROM TUBERCULOSIS IN DUSTY TRADES OF THE NATIONAL TUBERCULOSIS ASSOCIATION.

SUBMITTED TO THE EXECUTIVE COMMITTEE, PITTSBURGH, DECEMBER 5, 1918.

The following rather extended report has been arranged in a summarized form as a matter of convenience, not only for the membership of the committee but also for the information of the executive committee and the board of directors. It is a record of the committee's activity and the meetings held.

The Committee on Mortality from Tuberculosis in Dusty Trades was appointed by the president of the National Tuberculosis Association, in response to a resolution which was unanimously adopted by the board of directors. Under date of December 21, 1917, the following letter was addressed by the chairman to the members of the committee, outlining briefly the proposed plan and scope of the contemplated investigation, although necessarily in a rather tentative form:

> It affords me much pleasure to acknowledge your acceptance of membership on the Committee on Tuberculosis in Dusty Trades. It requires no argument of mine to emphasize to you the practical and far-reaching importance of more qualified technical consideration of this heretofore neglected aspect of the tuberculosis problem in this country. Your cooperation can be made of real value to the association which has extended to us this opportunity to give the matter official consideration. I would therefore welcome an early intimation of your viewpoint regarding the trades or occupations which in your opinion should receive prior consideration. It has been suggested that we might take up at the outset the question of tuberculosis frequency in the stone industry, selecting two or three recognized centers of its most important branches, such as granite cutting, marble cutting, and sandstone cutting. The slate industry in eastern Pennsylvania would seem to offer a very promising field. From another point of view it might be of real value to examine into the facts of actual tuberculosis frequency in the cement industry, which is comparatively free from the disease if the available statistical data and the special research work of Dr. Tucker can be relied upon. From much the same point of view a tentative inquiry might be made into the occurrence of tuberculosis among coal miners, say in the Scranton district, of which original investigations were undertaken by Wainwright and Nichols some years ago. Possibly after Dr. White's return from France he might help us with laboratory research in Pittsburgh, with special reference to the soft-coal mines of western Pennsylvania. The investigations which have been made by the Bureau of Mines and the United States Public Health Service in the zinc and lead mining districts of southwestern Missouri are suggestive of further study and analysis of mortality statistics and possibly the collective records of practicing physicians, hospitals, etc.

In the case of each and every one of these specialized studies it would seem necessary as a basic consideration that a thorough analysis should be made of the deaths from tuberculosis and respiratory diseases of persons aged 15 and over in the sections selected. This, of course, would require the cooperation of the local or State boards of health. Such experience as the writer has had is suggestive of the most hearty cooperation if the officials in charge are properly approached.

Aside from the occupations with exposure to inorganic dust, it would seem well at the outset to take up at least one occupation or industry with exposure to organic dust. Perhaps the most important of these is the cotton industry, and a comparative study might be made of the mortality of a representative mill town in New England and the South. The mortality analysis should be amplified by dust sampling, observations on temperature and humidity, and an individual as well as collective expression of qualified local medical opinion. The information which has become available with reference to the occurrence of tuberculosis in cotton spinning and weaving in this country as well as abroad suggests a much more thorough and impartial scientific study of the facts than has been made thus far.

The foregoing observations are merely tentative and an indication of the lines of research that suggest themselves to the undersigned as practical and promising of early results. It may be interesting in this connection that the United States Bureau of Labor Statistics expects to issue during the early part of 1918 an extensive bulletin by the undersigned on the mortality from respiratory diseases in trades with exposure to inorganic dust,[1] which it is hoped will prove of substantial value in the furtherance of the research herein indicated and officially approved by the national association in the appointment of our committee. There is a possibility that we can interest the Census Office in our work and secure much valuable technical aid and assistance may also be forthcoming from the United States Public Health Service and from the State boards of health, at least from Pennsylvania and Massachusetts, and possibly the Industrial Commission of Ohio. To the extent that such cooperation is secured our own work will, of course, be materially reduced in important matters of detail.

Preliminary to the sending out of this letter there had been a fairly extended correspondence with Dr. E. R. Baldwin, of the Edward L. Trudeau Foundation, with particular reference to a proposed investigation in the State of Vermont, and under date of November 7, 1917, Dr. Baldwin wrote to Dr. Hoffman as follows:

In view of the favorable attitude of the Vermont Marble Co.'s representative, Mr. Frank C. Partridge, and Dr. Caverly, of the State Board of Health, the investigation which I proposed to them would seem to be quite well received. I therefore am inclosing a preliminary outline of the kind of study that seems to me worth while for your criticism and suggestions. I hesitate to trespass upon your time for this, but knowing your interest and the number of things that from your standpoint you would like to see covered, I am sure you can be of great assistance in suggesting further inquiries or the elimination of those that seem hardly worth while. The work might be done largely at the Vermont Sanatorium at Pittsford, where Dr. E. J. Rogers is resident physician. In conversation with one of the trustees (Dr. James) I find him quite favorable toward a grant from the Trudeau Foundation for this purpose, and we could probably furnish an assistant under the fellowship plan for the carrying on of the work at the sanatorium as a center. The permission of the granite industry would have to be obtained, although I think it could be secured without great difficulty. I would welcome any criticism or suggestion you might make before making the final plan for this work.

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[1] Hoffman, Frederick L.: Mortality from respiratory diseases in dusty trades (organic dusts). Bull. 231, Bureau of Labor Statistics, U. S. Department of Labor. Washington, 1918.

This letter made it clear that Dr. Baldwin had anticipated the work of the committee by taking the initial steps of an original investigation which had, in fact, been quite fully discussed at the meeting of the board of directors of the association when the resolution for the appointment of the committee was adopted. The plan proposed by Dr. Baldwin is restated in its entirety below:

INVESTIGATION OF THE EFFECT OF THE MARBLE AND GRANITE INDUSTRIES ON TUBERCULOSIS.

HISTORY AND STATISTICAL INQUIRY FROM THE VERMONT BOARD OF HEALTH AND THE UNITED STATES MORTALITY TABLES.

1. Incidence and mortality from tuberculosis among workers:
    - (*a*) Dry cutting.
    - (*b*) Moist cutting.
2. Personal inquiry from employees in industries, with family histories:
    - (*a*) Dry cutters.
    - (*b*) Wet cutters.
3. House to house census by medical inspectors of present and past illnesses among families of cutters:
    - (*a*) Age.
    - (*b*) Race.
    - (*c*) Residences.
    - (*d*) Various employments, past and present, of tuberculous.
    - (*e*) Various employments, past and present, of nontuberculous, especially other chest diseases.
    - (*f*) Duration of employment.
    - (*g*) Present condition of employees:
        - (1) Apparently well.
        - (2) Those suffering from ailments, especially chest or throat affections.

MEDICAL EXAMINATIONS.

1. All who show symptoms or a history of chest disease:
    - (*a*) Chest examination.
    - (*b*) Sputum examination (if present).
    - (*c*) Families of those who have tuberculosis.
2. Röntgenograms of all who have chest affections:
    - (*a*) Röntgenograms of 25 dry cutters who are apparently well.
    - (*b*) Röntgenograms of 25 wet cutters who are apparently well.
3. Calcium determinations in urine of 10 healthy dry cutters in marble industry.
    - (*a*) Calcium determinations in urine of 10 healthy wet cutters or any other nondusty employment.
    - (*b*) Calcium determinations in sputum of 5 dry cutters who have bronchitis.

Inspection and description of working conditions.

Determination of amount (weight and bulk) of dust in terms of cubic feet of air in dry cutting rooms in—
- (*a*) Winter.
- (*b*) Summer.

Methods of ventilation.

Respirator devices described.

Habits of workers.

Use of exhaust devices.

Under date of December 26, 1917, Dr. E. R. Baldwin amplified his previous communication in part as follows:

> Your suggestions about the scope of the investigation are certainly very interesting and valuable. The bearing of this problem upon organic dust is of course so widespread, and I have so little knowledge on it, that I think I could be of very little use in that particular in my situation. There is one point that occurred to me in connection with the investigation of industries, and that is the possibility that the United States Public Health Service would be engaged in the same thing and possibly at the same time, or if not, would have plans for this work.
>
> I have no doubt that your forthcoming statistical study would be the best starting point of any investigatiou, and until this is available I presume there will be little done. I was assured by Dr. Caverly in Vermont of the cöoperation of the State board of health, including some clerical aid. Dr. Rogers, superintendent of the sanatorium in Pittsford, was the man I had in mind to take charge of the medical and X-ray work. He is a good diagnostician, but would need assistance and guidance in planning out a survey. The Vermont Marble Co. has indicated its willingness to give us every facility, but the granite industry is less easy to deal with, from what I have heard.

In his reply to this letter, under date of January 3, 1918, Dr. Hoffman enlarged upon certain practical aspects of the proposed investigation, in part, as follows:

> I am obliged to you for your favor of December 26 and the fairly extended expression of your views regarding the plan of procedure on the part of the committee on dusty trades most likely to prove productive of practical and early results. It seems to me that the work that you have in mind is most promising and in accordance with my own ideas regarding the prior importance which should be given to the stone industry. I feel with you that a limited but thorough investigation of a few typical dusty trades would be more acceptable to the association than a rather superficial study of a larger number of trades and occupations, however attractive the latter might be from other points of view. A considerable amount of new material will be forthcoming as soon as my bulletin on The Mortality from Respiratory Diseases in Dusty Trades with Exposure to Inorganic Dusts is published.
>
> In your letter of November 7 you referred to the favorable attitude of the Vermont Marble Co. and the anticipated active cooperation of the Vermont State Board of Health. This seems to me a most auspicious indication of the assistance which will be forthcoming in the furtherance of our plans when presented in the proper way to those directly concerned. It has always been my own method to utilize such agencies as could be made use of to secure the information desired and to give full credit for such cooperation in the conclusions arrived at. In Vermont we would have both the marble and the granite industries, and possibly some attention could be given to slate quarrying, cutting, etc., which is of some importance in that State. Of the slate sold in the United States during 1915, out of a total value of about $5,000,000, $1,250,000 was derived from Vermont. The production, however, has been declining in that State during recent years. Vermont in 1915 was the fourth most important stone producing State, being slightly exceeded by New York and Ohio but considerably by the State of Pennsylvania. There were 49 active plants in operation, indicating that the number employed to a given quarry, mill, etc., was larger than in most of the other States. In granite production, however, Vermont was the leading State in 1915; in marble it was also the leading State, in fact, far exceeding in the value of the product any other State. It would therefore seem entirely safe to assume that conclusions based upon an investigation in Vermont with reference to the granite and marble industries and possibly with reference to the slate industry should be

sufficiently representative for the country at large, and I would be pleased to join with you in an active effort to subject the local conditions to a thorough investigation, in so far as our own office can be of assistance to you. In other words, I would be inclined to agree that at the outset at least, or say for the present year, most of the work of the committee should be limited to the State of Vermont, more or less in conformity to the admirable outline attached to your letter of November 7, and which bears the title "Investigation of the effect of the marble and granite industries in tuberculosis."

First in the order of logical procedure, it would seem to me, a thorough study should be made of working methods or processes and labor conditions. How far present methods have been made a matter of descriptive accounts in trade journals, etc., I am not aware, but I feel reasonably sure that there would be no serious difficulties in obtaining at least at the outset a fairly comprehensive account, amplified by the required illustrations of the principal machines used in dry cutting, moist cutting, etc. In this connection we have available the results of a personal investigation made by myself some years ago into the conditions in Vermont and of which we will make an effort to secure a duplicate copy for your information. As regards personal inquiry among employees in the industries referred to and with special reference to family histories, it would be advisable to proceed with extreme caution, upon the basis of an exceptionally carefully considered blank. Many such investigations have failed in the past in that either the blanks themselves were improperly worked out or that the inquiry was not made with the required persistency. We had some experience in this connection with an investigation made by Miss Janice Reed in behalf of the Phipps Institute in the clothing industries in Philadelphia. The blanks and forms used by her at the time should prove useful in connection with the Vermont investigation, and copies thereof will be obtained and forwarded later on, together with a copy of the report itself, with reference to which I may explain that the analysis was made in my office and that the blanks were printed at our expense and the work itself in a general way was done under my direction.

The same observations apply to house-to-house censuses by medical inspectors with reference to the present and past illnesses among the families of cutters. I, however, feel that the entire industry should be included in this investigation, for as possibly to be emphasized later, occupational changes make it exceedingly desirable to include those who are now perhaps following harmless pursuits, but who formerly followed occupations of a harmful nature. Collis, in the Milroy lectures on dust phthisis, gives as an illustration the case of a lung of an insurance agent who for eight years before, however, had been a miner in the Transvaal, etc. If the autopsy had not been made, or if the previous occupation had not been ascertained, the conclusions in either event, or both, would have been misleading.

I construe the term "race" (under letter "*b*") to mean racial origin, or, rather, parent nativity. The blank should show the birthplace of the father and the mother as well as the birthplace of the person questioned. This section should be revised and if possible made more specific, so as to admit of categorical answers more suitable for statistical analysis.

As regards the medical examination, I am emphatically of the opinion that if any way possible all employees should be examined, whether they show symptoms of past history of chest diseases or not. The method pursued by the miners' phthisis commission of South Africa should, if possible, be followed in matters of detail, so that if practicable the results may be comparable. A copy of the report of the commission, if not available to you, can be loaned to you by the library of the United States Commissioner of Labor Statistics.

The same observation applies to the determination of the amount (weight and bulk) of the dust in terms of cubic feet of air in dry cutting rooms, but I would broaden this to include all cutting rooms, and, furthermore, that the determination be in conformity to the more or less standardized method of the South African investigation or the Australian investigation, or those made in England in behalf of the Royal Commission on Metalliferous Mines

The methods of ventilation, dust-exhaust devices, respirators, of different types, habits of the workers, with special reference to dust removal, cleanliness of the plant, sweeping, etc., would indicate highly differentiated lines of inquiry, which it would be best to develop with increasing experience in the gathering of this kind of information. It is possible that the American Museum of Safety could be utilized with reference to securing a complete list of respirators, of which, unfortunately, a large number have been found impracticable in actual use or otherwise objectionable on the part of the workmen.

A collateral study should be pneumatic tool processes, which, of course, as you know, have been even more extensively developed in connection with underground mining than with cutting and polishing in the stone industries. The cooperation of manufacturers could, no doubt, be secured later on, as the facts would develop, for of course we must keep in mind throughout the importance of practical results. It would be of small use to emphasize an evil or condemn existing processes or practices unless an alternative could be suggested, but if possible one acceptable to the theoretical as well as eminently practical point of view.

On the basis of the foregoing, I shall proceed with our own preliminary office investigation. All that we have on the subject of the granite and marble industries will be brought together and subjected to critical consideration. When available a preliminary report will be sent to each member of the committee.

Referring now to your letter of December 26, it seems to me that the strictly technical work should be entirely under your personal direction, and subsequently we might so organize our committee as to make you the chairman of a subcommittee of one on medical examinations and laboratory analysis. I would personally be willing to take charge of the general industrial conditions, working processes, and sickness and mortality statistics. After you have worked out your own plans somewhat further and mine has been developed a meeting could be arranged for either at Saranac or perhaps at Burlington, at the office of the State Board of Health, to be followed by a joint interview with the managers of the industries whose cooperation has been promised. I should judge that during March or April such a conference could be arranged for in Vermont, to be followed later by others as occasion may require.

In the meantime the fact had developed that an exceptionally thorough investigation was being made in the State of Indiana, jointly, by State and Federal health authorities, etc., in cooperation with employers of labor in the limestone industry of southern Indiana. Under date of January 8, 1918, the following letter had been received by the chairman from Mr. R. M. Richter, the secretary of the Bedford Stone Club Auxiliary:

Please advise us whether the rate you make stonecutters differs substantially from rates in other vocations. If there is a difference, we would be glad to have you say, if consistent, why. Are there any reasons other than the prevalence of dust in some stone-working establishments which perhaps cause you to discriminate in rates or otherwise against this class of labor? A prompt reply will be very much appreciated.

To this letter, under date of January 15, 1918, the following reply had been made, though limited, of course, to the injurious consequences of dust inhalation, which in the investigation under way was a matter of minor consideration:[1]

> This occupation has been investigated by us from time to time with reasonable thoroughness, but not sufficiently so to justify final scientific conclusions. The writer is chairman of the committee on the Scientific Investigation of the Mortality from Respiratory Diseases in Dusty Trades appointed by the president of the National Tuberculosis Association, which has in contemplation an original investigation along strictly scientific lines, and as far as practicable in conformity to the method of procedure followed by the Phthisis Commission of South Africa. The writer's earlier observations and statistical data are contained in Bulletin No. 79 of the United States Bureau of Labor, of which a copy may possibly be obtained through the Superintendent of Public Documents, since the general issue has long been exhausted. A revised issue is now in course of preparation and will be available in perhaps six months in proof form through the courtesy of the Commissioner of Labor Statistics. This volume is exclusively devoted to mineral dust. The data and observations, however, are rather general, since an opportunity did not present itself to go into the details by means of field investigations, which would have required visits to the principal centers of the stone industry and a reexamination of death certificates with practicing physicians familiar with the facts of local disease incidence and its relation to highly specialized industrial processes. For your information we give below our rating practice with regard to stone and marble workers, as published in our latest rate book (August, 1917):
>
> | | |
> |---|---|
> | Paving-stone cutters | Endowment plans, medium. |
> | Quarrymen, open or surface work | Medium. |
> | Quarrymen working underground | Endowment plans, medium. |
> | Stonecutters not using pneumatic tools | Endowment plans, medium. |
> | Stonecutters using pneumatic tools | Endowment plans, hazardous. |
> | Stone sawyers, and lathe workers, polishers, and finishers | Endowment plans, medium. |
> | Tool sharpeners | Medium. |
>
> These ratings, however, are not conclusive concerning the point of view in which you are likely to be most interested, in that for practical reasons we can not differentiate the minor employments which would be most exposed from the major branches of the industry with a relatively small degree of dust exposure. We give below the premium charge at age 30 for the different classes as well as the normal charge in occupations without exceptional hazards:
>
> *Annual premium, $1,000 insurance; age 30; twenty-year endowment.*
>
> | | |
> |---|---|
> | Regular rate | $42. 35 |
> | Paving-stone cutters | 44. 75 |
> | Quarrymen, working underground | |
> | Stonecutters, not using pneumatic tools | |
> | Stone sawyers, lathe workers, polishers, finishers, and tool sharpeners | |
> | Stone cutters, using pneumatic tools | 47. 16 |

From a letter received from Mr. Richter under date of January 19, 1918, in reply to Dr. Hoffman's letter of January 15, the following extract is quoted, as an illustration of views prevailing at the present time concerning the apparent harmlessness of dust inhalation in consequence of the use of pneumatic tools in the limestone industry of southern Indiana:

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[1] The results of the Indiana investigation have since been published as Reprint No. 460 of the United States Public Health Service. The reprint contains three reports, respectively, by Passed Asst. Surg. J. P. Leake, on "Health hazards from the use of the air hammer in cutting Indiana limestone"; one by Dr. David L. Edsall, on "The supposed physical effects of the pneumatic hammer on workers in Indiana limestone"; and one by Dr. Alice Hamilton, on "The effect of the air hammer on the hands of stonecutters."

> Drs. Barnes, Leake, and Edsall are unanimous in their finding that the prevalence of dust in the mills of the Indiana limestone district is a negligible factor. This because the stone as worked here is drenched with water at various stages of fabrication, which water is not evaporated to any extent until the stone is practically ready for loading. These doctors are further agreed that the general health of all the stonecutters examined and interviewed here is exceptionally good and that without question or doubt they rate much higher in that regard than stonecutters generally.
>
> It seems to us, therefore, that the matter to which we refer hereinbefore must be of vital interest to you. Our interest in it is twofold. We want to show in all fairness that the effects of the pneumatic tool are not such as to warrant discrimination. We want further to create for our workmen a condition which will give them every benefit so far as insurance, among other things, is concerned, which may rightly accrue from the fact, first, that the pneumatic tool does not imply hazard and, second, that in our operations in Indiana tuberculosis owing to dust is practically, if not entirely, an unknown experience.

With further reference to this exceptionally favorable view regarding the local situation, the following extract from a letter of Mr. Richter's dated January 25, 1918, is also included:

> When you come to Bedford, you will find the mills are almost altogether of a strictly up-to-date character, so far as equipment in general and working conditions are concerned. As a matter of fact, we believe we can show with some force that in the absence of a personal examination of the facilities here no true conclusion can be reached regarding our particular situation. In passing, we want to refer to the fact that tuberculosis unquestionably is far more prevalent in the granite and sandstone industries than in the Indiana limestone industry. Not only are our accommodations more modern than generally found elsewhere, but the nature of the stone itself is such as to preclude most of the detrimental elements which are a source of objection in other sections of the business. Indiana limestone, as commonly worked, is moist, in fact, one may say, wet. Furthermore, its physical make-up is such as to cause an almost total absence of sharp, gritty particles which, according to my understanding, are the chief objection in granite and sandstone. I have in mind, upon the occasion of your visit here, whenever it is, to call a meeting of all the cut-stone firms, so that if you care to you can give them a talk on the whole proposition, or at least as far as you may wish to go into it.

In the meantime correspondence had been had with the general secretary and treasurer of the Journeymen Stonecutters' Association of North America, Mr. Walter W. Drayer, of Indianapolis, under date of February 2, 1918, reading as follows:

> Replying to your favor of the 29th ultimo, will say that I have no special reports as to the health and to the injuries suffered by our members from the use of the pneumatic hammer. It is true that our members do suffer a partial paralysis of the hands in the use of the pneumatic hammer, and this condition has brought forth a determined complaint by our membership. However, we have no data to submit at this time, but within the course of the next few weeks the Department of Labor will issue a special bulletin upon the subject, the department at this time being engaged in conducting a rigid examination to determine just the effect of the use of this tool upon the man who uses it.

To the foregoing letter the following reply was made under date of February 6, 1918:

We are obliged to you for your favor of February 2, and the information contained therein regarding the forthcoming report of the Bureau of Labor Statistics on the effects of the use of the pneumatic hammer on certain bodily functions, especially the use of the hands and the arms. We hope to have an opportunity to examine this report in the near future at Dr. Meeker's office in Washington. I have arranged for an interview with Dr. Hamilton, with whose work we are thoroughly familiar.

It has occurred to the writer that perhaps you would be willing to discuss this matter with the undersigned, not only as regards the rather limited aspects of the particular question just referred to, but as to the broader questions involved, such as the general mortality of stonecutters in Indiana, the apparent excess from pulmonary tuberculosis and other respiratory diseases, etc. The general subject of stoneworkers' mortality will be discussed in a forthcoming bulletin of mine on The Mortality from Respiratory Diseases in Dusty Trades, limited for the present to dust of mineral origin.

Does your association transact life insurance or does it grant sick benefits, and, if so, are the mortality or morbidity data available in a form for statistical analysis? If your association should have a considerable amount of information on the subject it might be feasible for the committee and our company to cooperate so as to bring to light much useful information on the health of the men in this industry or rather the possible health-injurious aspects of the work in which they are engaged. The committee on the scientific study of the dusty trades with special reference to tuberculosis recently appointed by the National Association for the Study and Prevention of Tuberculosis, and of which I have the honor to be the chairman, is most anxious to secure the cooperation of your association, aside from the cooperation which is likely to be extended to us by the State board of health and the leading stone producing industries.

In connection with our investigation I expect to visit Indiana and I could, of course, easily arrange to see you and discuss this matter in more detail. I rather regret to learn that you have as yet made no special investigation on your own part as to the health and the injuries suffered by your own employees from the use of pneumatic tools, but possibly this reference does not cover the broader question of health-injurious conditions in the stone industry of Indiana in general.

To this letter Mr. Drayer, February 9, 1918, replied at considerable length. His letter is a notable contribution to the scientific study of industrial diseases from the labor point of view, and the letter is given in its entirety, even though some of the observations relate to the physical effects of the use of the pneumatic hammer on the health of the workers in Indiana limestone as a problem separate and distinct from the broader questions involved in the present discussion:

Your valued favor of the 6th instant at hand this morning and contents very carefully noted. In reply will say that I will cheerfully favor you with any information we have relative to the use of the air or pneumatic hammer and the physical injuries suffered by our members who use it, also any data you may desire as to the mortality of our membership.

With reference to the air hammer, it has been a momentous question with our membership for the past five years, owing to its almost universal installation in many localities throughout the country. We have not conducted any specific investigations in regard to this tool for several reasons, namely, that the employers maintain that our opposition to the tool is solely because it has proved efficient and that we are afraid it will displace a number of our mechanics; that no matter how unprejudiced an investigation we might conduct, the employers would go to extremes to discredit it; that the subject to us is one that needs no specific investigation, inasmuch as fully 90 per cent of our members who have been using this tool for a year or more show the visible effects which can not be denied, inasmuch as the circulation in their hands and arms becomes stagnant and as a result on a cold and damp morning their hands and fingers seem absolutely lifeless, turning a pale white color, best illustrated by comparing it to the hands of a corpse. We have therefore prevailed upon the United States Government to make an investigation of this general complaint, knowing that such report could not be discredited by the employers, which would be the case should we conduct an investigation. I am by this mail forwarding you copies of our 1917 Journals in which I have marked several articles bearing upon our observation of the use of this tool, also containing general summary of Dr. Charles Cottingham, of this city, whom we employed to make an examination of some seven or eight of our members. In these Journals you will also find extracts of items appearing in the "Minutes," a pamphlet published by the International Cut-Stone Contractors and Quarrymen's Association. By writing to Mr. Wm. A. Guthrie, secretary of the International Cut-Stone Contractors and Quarrymen's Association, 1 East Forty-second Street, New York City, you might be able to get the back numbers of this publication and thus obtain a clear understanding of the attitude of the employers upon this tool.

As to the susceptibility of our members to tuberculosis, I may advise you that a few years back, when a great deal of the work was in sandstone, the death rate of our members from tuberculosis was alarming. However, of late years sandstone has not been so extensively used, Indian oolitic limestone in a great measure supplanting the use of sandstone, and as the bulk of the work in Indiana limestone is done with machines and the analysis shows limestone to be composed of about 98 per cent lime, we find that our death rate of tuberculosis is steadily decreasing. I might add, though, that the use of the pneumatic hammer subjects our members to more danger in the contracting of tuberculosis than do the tools of our trade—the mallet and hammer—inasmuch as the vibration or stroke of this hammer is constant, thus emitting a steady stream of this fine dust into the face and nostrils of the operator, while with the tools of the trade there was, of course, an interval between the blows which gave the dust some opportunity of being carried away in the air.

We have since the organization of our association paid our members a death benefit, and of course a record has been kept of all such claims. I am sorry to say, however, that this record was not in the past kept in the complete manner it should have been kept, as a great number of deaths recorded do not show cause of death and age of deceased. However, a majority of the deaths show a complete record and it is, of course, possible to obtain statistics on the percentage thus reported.

I note that you are contemplating a visit to Indiana, and if you will visit this city during your investigation in the State I will be only too pleased to meet you and give you all information possible. In the meantime it is possible that I will be in New York some time during the month and if agreeable I would be pleased to call at your office and talk over these subjects with you, as it is evident that we must obtain some relief from the present inhuman manner in which a number of the employers would force our members to use these tools. I feel satisfied that should you see Dr. Meeker and Dr. Hamilton they will be in a position to supply you with much valuable information relative to the air hammer and we are very much in hope that the medical examination of several of our members now being conducted in Chicago by Dr. Rothstein will be shortly completed so that we may get the complete report of the Bureau of Labor Statistics upon this subject.

Assuring you that I am only too pleased to assist you in any way possible in your investigation of health conditions in the stone trade in Indiana, I am, etc.

The reply to the foregoing communication, under date of February 15, 1918, reads in part as follows:

> It was very good of you to write to me at length regarding the subject matter referred to in my letter to you of February 6. Your presentation of the matter in controversy is an admirable indication of your sense of fairness and your desire to have the true state of affairs ascertained by means of an impartial inquiry. You have certainly adopted probably the only course open to you by making use of the expert services available through the Bureau of Labor Statistics. There is not a more qualified person in this country in connection with such matters than Dr. Alice Hamilton and her report will unquestionably set forth the facts in the case with scrupulous accuracy and scientific conclusiveness. Of course, in every question of this kind there are matters in controversy which permit of more than one well-considered point of view, so that it is most desirable indeed that the manufacturers, on their own account, should have initiated similar inquiries, which ought to prove productive of good results. I understand that they have retained Dr. Edsall, who is one of the foremost authorities on occupational diseases and whose judgment and conclusions should be of real value.

Mr. Drayer made anwser to the preceding communication under date of February 23, 1918, but on account of urgent office matters the proposed conference could not be arranged for, nor could the contemplated investigation in Indiana be carried out at the time, although additional assurances of local cooperation had been received from Dr. J. N. Hurty, the secretary of the Indiana State Board of Health:

> Your valued favor of the 15th instant at hand and contents carefully noted. In reply will say that just as soon as I have the opportunity of being in New York City I will call you over the phone and make arrangements to meet you either in New York or at your office in Newark.
>
> I fully expected to be in New York prior to the end of this month. My mission there was in connection with a matter in the Federal court, but I believe there has been some postponement of the case, and I can not predict just when the matter will again come up.
>
> However, just as soon as I have occasion to visit New York I will get in touch with you and will be pleased to bring along such records of our association as will enable you to draw conclusions as to the percentage of our members who have died of tuberculosis as a result of the dust connected with the cutting of stone.

(Useful references but particularly with regard to the effect of the air hammer on the hands of stonecutters, but with some observations on pulmonary tuberculosis, occur in the January, March, May, June, August, and September, 1917, issues of The Stonecutters' Journal.)

The preliminary work having been completed the first meeting of the committee was called to be held at Saranac Lake, following the executive committee of the National Tuberculosis Association, called for July 13, 1918. In a communication to the members of the committee, dated June 25, 1918, the proposed plan of investigation was briefly outlined as follows:

> This is to inform you that, if in any way possible, a meeting of the committee on dusty trades will be held at Saranac Lake either before or after the meeting of the executive committee. Since at this time the date is somewhat uncertain, but tentatively assumed to be July 13, the meeting could probably be held Sunday after-

noon or perhaps Saturday evening. Dr. B. R. Baldwin has been at work on experimental research, in cooperation with the State Board of Health of Vermont, and no doubt definite recommendations could be made as to the nature of the work to be taken up by the committee. Dr. Lanza, of the Public Health Service, in cooperation with associates of the Bureau of Mines, has just published a report on Silicious Dust in Relation to Pulmonary Disease, which should be useful. Much to my regret my own rather extended report on Occupations with Exposure to Inorganic Dusts and Their Relation to Pulmonary Diseases is not yet available, but the final page proof has been released for the Public Printer.

The main questions to be taken up are, briefly, as follows:

1. What occupations or industries should be taken up at the outset? Would it not be possible to limit the work of the committee at this time to certain well-defined employments in the stone industries, such as the marble and granite quarries of Vermont, the limestone industries of southern Indiana, the zinc and lead mines of southwestern Missouri, and possibly the cement industries and perhaps the slate industries of Pennsylvania?

2. How far would it be possible to secure the active cooperation of the State Boards of Health of Vermont, Pennsylvania, Indiana, and Missouri? Some gratifying assurances have been received, especially from Vermont and Indiana.

3. What field investigations should be undertaken at this time and how far would it be possible or practicable to secure the active cooperation of the Federal Health Department, the Bureau of Labor Statistics, the Bureau of Mines, etc.?

4. How far would it be possible for the Trudeau Foundation to cooperate, or conversely, in what direction could the work of the committee be best coordinated to the admirable work which is being done by Dr. Baldwin and his associates?

5. Would it be feasible—and if so, would it be advisable—to undertake a special analysis of death certificates in certain centers of the stone or cement industries for the purpose of subjecting the data to a qualified examination, especially as regards accuracy in occupational returns and accuracy in the clinical diagnosis and correctness in death certification?

6. How far would it be possible to take up the question of autopsies, especially with the cooperation of the Henry Phipps Institute and possibly the Mellen Institute of Pittsburgh? The occupational disease clinic of the University of Pennsylvania might also be utilized. A question which might be taken up would be as to how far a thoroughly complete series of autopsies of stone and cement workers, including miners, could be brought together, amplified by a complete chemical analysis of the lungs, in conformity to the procedure of the miners' phthisis commission of South Africa, etc. If a descriptive account of even only a score of such lungs could be secured with full occupational details, dust exposure, occupational processes, etc., much new knowledge might be gained.

7. How far would it be possible—and if so, desirable—to take into special account the question of the degree of fineness or minuteness or size of the dust particles inhaled under different occupational conditions as different and distinct from the quantative determination of the dust contents both of the air and the lungs, as has usually heretofore been the case in investigations of this kind? The work of the South Africa Commission seems to have proved conclusively that the degree of fineness or minuteness of the dust particles is of far greater importance than the mere quantity of the dust inhaled during different occupational processes.

These are merely tentative suggestions so as to provide an orderly basis of procedure for the deliberations of the committee. Any other questions could of course be brought up at the meeting.

At the meeting the following brief report, which was originally communicated to the executive committee under date of March 15, 1918, summarized what had thus far been done:

REPORT OF THE CHAIRMAN OF THE COMMITTEE ON THE SCIENTIFIC INVESTIGATION OF THE MORTALITY FROM TUBERCULOSIS IN DUSTY TRADES.

There has thus far been no meeting of the committee, but a rather extended correspondence has been carried on with the members, who, one and all, are showing an active interest in the proposed investigation. Dr. Alice Hamilton has accepted membership and her cooperation will be most useful. She has agreed to include a study of the question of tuberculosis in its relation to the use of pneumatic tools in her general investigation of the stone industry in Vermont. For the time being attention is concentrated upon the limestone industry in southern Indiana. Most gratifying assurances of cooperation have reached us from manufacturers and labor unions, as well as from the United States Bureau of Labor Statistics and the United States Public Health Service, which are at present engaged in a thorough scientific study of the mechanical effects of pneumatic tools. The investigations will be enlarged in certain directions, in accordance with our suggestion, to include the subject of tuberculosis. It had been the intention of the chairman to make a personal investigation in southern Indiana before this, but it is doubtful whether this can be done before May or June. Among other conferences was one recently held with Dr. Leake, of the United States Public Health Service, whose investigations in southern Indiana included the question of tuberculosis and whose preliminary report will be published in the near future.

The outlook is therefore encouraging that really useful work will be done by the committee during the summer months. In the meantime the chairman's rather extended report on the Mortality from Respiratory Diseases in the Dusty Trades, with special reference to Inorganic Dusts, in course of publication by the United States Bureau of Labor Statistics, is reaching completion, and should be available before June 1.

Respectfully submitted.

FREDERICK L. HOFFMAN,
Chairman Committee on Mortality from Tuberculosis in Dusty Trades.
National Association for Study and Prevention of Tuberculosis.

Under date of July 17, 1918, the minutes of the meeting and the results of the conference were communicated to the president of the association, as well as to the members of the committee, for future reference and as a basis for future deliberations, as follows:

DR. DAVID R. LYMAN,
President, National Tuberculosis Association,
Wallingford, Conn.

MY DEAR DOCTOR LYMAN: The following is a brief statement of the conclusions and recommendations arrived at by the Committee on the Scientific Investigation of the Mortality from Tuberculosis in Dusty Trades, at their recent meeting at Saranac Lake, with such observations concerning matters of detail as may prove useful as a matter of record.

The meeting was participated in by Dr. A. J. Lanza, of the United States Public Health Service; Dr. Edward R. Baldwin, of Saranac Lake; Dr. Alice Hamilton, of Hull House, Chicago; Dr. O. W. McMichael, of Asheville, N. C.; and by invitation, Dr. Charles S. Caverly, president of the Vermont State Board of Health; and Dr. Gardner, of the Research Department of the Trudeau Foundation, Saranac Lake.

In a general way, the committee considered first the question as to what occupations or industries should be taken up; second, what special aspects of the problem should be given priority; third, what special methods of investigation, if any, should be followed; and, fourth, what official or private assistance or cooperation should be secured.

The committee took cognizance of an investigation contemplated by Dr. E. R. Baldwin and his associates in behalf of the Trudeau Foundation into the relation of the marble and granite industries to tuberculosis, with special reference to the State of Vermont. In the furtherance of this plan, presented in some detail and placed before the committee for its consideration, the active cooperation of the State Board of Health of Vermont had been secured, as well as that of the Vermont Marble Co., and particularly that of its representative, Mr. Frank C. Partridge.

The importance of the stone industries in their relation to the tuberculosis problem was emphasized by the chairman, who directed attention to a forthcoming and rather extended publication of the United States Bureau of Labor Statistics, on the mortality from respiratory diseases in their relation to the dusty trades, limited, however, to inorganic dust. The evidence brought together in this work fully sustains the viewpoint of Dr. Baldwin and others, that if at all practicable, the stone industries, and particularly the marble and granite industries, should be given priority in the deliberations of the committee.

Dr. Caverly presented a statistical statement regarding the stone industries of the State of Vermont, pointing out in detail that the number of granite cutters in the Barre district, including helpers, and men employed in quarries, was approximately 5,000. In the city of Barre, with a population in 1910 of 10,784, there had been 135 deaths from all causes, and that of this number 28, or 20.7 per cent, had been caused by tuberculosis of the lungs; and 33, or 24.4 per cent, by some form of tuberculosis. This excessive proportion of deaths from tuberculosis was fully sustained by the evidence in detail, and for a period of years regarding the frequency of tuberculosis among the general population of the granite-cutting industries, not only of Vermont, but of the country at large. It was agreed as a tentative conclusion that mechanical and other operations necessary in the conduct of the stone-cutting industry were in some way and in some measure, and possibly in a large measure, responsible for the excess in the frequency of tuberculosis occurrence in the stone-cutting sections of the State of Vermont.

Regardless of the frequency of tuberculosis in the stone-cutting sections, counties or towns, of the total number of admissions to the State sanatorium for incipient tuberculosis during a period of about ten and a half years, and numbering 963 patients, only 56, or 5.8 per cent, have been granite cutters, granite workers, or quarrymen. In addition thereto, the number of marble tracers, graders, polishers, cutters, and workers admitted to the institution since its opening has been only 10. In view of the fact that these two stone industries are probably the most important industrial enterprises in the State, it is self-evident that the institution is not being utilized as much as it should be, and most of all not on the part of those afflicted workers suffering from the disease in the incipient and curable stages.

Dr. Caverly, in conclusion, stated that the outlook was encouraging that the manufacturers, especially those engaged in the marble industries, would welcome a scientific investigation, and that a similar amount of support would probably be forthcoming with the Granite Manufacturers' Association, and especially its secretary, Mr. Hinman, of Barre City.

Dr. Baldwin said in this connection that much valuable assistance could be rendered through the Vermont Sanatorium at Pittsford, and particularly its resident physician, Dr. E. J. Rogers, whose services might be made available through the cooperation of the Trudeau Foundation in the direction of certain highly specialized phases of field research.

Dr. Lanza raised the general question as to the use of pneumatic tools and the best possible means of reducing or controlling the health-injurious consequences of their extensive employment in the stone industry. Dr. Caverly called attention to a safety device which, a few years ago, had been offered but had been rejected on the ground that it materially increased the weight of the tools and was therefore objectionable to the employees. He agreed to furnish a photograph of the proposed device, with a view to a further consideration of this question, particularly on the part of the manufacturers, especially the Ingersoll-Rand Co. Dr. Caverly also recalled that at the time a fairly extensive correspondence had been had with those directly interested in the problem and possibly some of this correspondence might later be made available to the committee.

Dr. Hamilton referred briefly to her investigations in the Barre district, limited, however, largely to the mechanical injuries resulting from the use of pneumatic tools and made only incidentally with reference to the dust hazard and its relation to the occurrence of pulmonary tuberculosis. She gave expression to the view that the labor unions would be favorable to an investigation if approved of by the president of the International Union, with headquarters at Quincy, Mass. It was felt by all those present that the fullest cooperation of both employers and employees could be had from the outset in any possible field investigation.

The question was then taken up as to the first section of Dr. Baldwin's proposed plan of investigation, having chiefly to do with external or environmental factors, including housing conditions, age, race, duration of employment, etc. It was agreed that such a field investigation should be made more or less in conformity to the plan of inquiry followed by Dr. Forrest B. Ames in his "A tuberculosis survey of the residents of Saranac Lake, New York," made available to the members as a reprint from the American Review of Tuberculosis for June, 1918. It was agreed, however, that the blank utilized for the purpose would require to be materially modified, and it was further agreed that the chairman would have such a blank prepared, based upon similar inquiries in this and other countries and forward tentative copies to every member of the committee previous to the next meeting. Dr. Lanza suggested in this connection that possibly the blanks used by him in the joint investigation of the United States Bureau of Mines and the United States Public Health Service, in southwest Missouri, and at Butte, Mont., might be utilized. He was requested to forward copies of such blanks to the chairman.

Dr. Caverly then suggested that possibly the State health inspectors could be made use of in securing the required information by a house-to-house survey; if not of an entire district or town, at least of a typical portion thereof. He thought further that the State Tuberculosis Department, through its educational division, might render useful personal assistance, and he agreed to give this matter further consideration. Dr. Lanza said that on the basis of his experience woman field investigators had been found particularly useful, and his view was sustained by the chairman and others present participating in the discussion. Exceptional care, however, would be required in the employment of a field worker, aside from the question as to compensation and other expenses. Dr. Caverly suggested the preparation by the chairman of a brief memorandum for his use in presenting a proposed plan of cooperation to the Vermont State Board of Health for its official approval. This was agreed to by the chairman, and copies of such a memorandum were subsequently to be sent to every member of the committee.

It having been agreed that a field investigation would be necessary to ascertain the general facts of the industry and the general effects of the employment upon the physical, social, and economic condition of the people, the committee proceeded with a consideration of the second portion of Dr. Baldwin's outline, concerning chiefly the medical or physical examination of the employees. It was agreed that such an examination should be made of as large a number of employees as could possibly be induced to submit to a thorough examination. Dr. Hamilton felt that if the cooperation of the Granite Cutters' Union and of other labor unions was secured the difficulties would not be as serious as anticipated. Dr. Lanza said that in the light of his experience much would be gained if the physical examinations were conducted under the direct authority of some member of a department, like the United States Public Health

Service, the United States Bureau of Mines, or the United States Bureau of Labor Statistics, rather than to be made to rest entirely upon the basis of a private and unofficial initiative.

Dr. Baldwin enlarged upon the practical side of the required Röntgen-ray examinations, which all of those present considered absolutely essential. Reference was made to the elaborate study of this phase of the problem by Drs. Pancost and Miller, and by Dr. Landis, the latter being a member of the committee, but unfortunately unable to be present. The Trudeau Sanatorium, or the Trudeau Foundation, would be willing to undertake much if not most of this work and materially share in the expense. It was agreed, however, that the physical examination of the employees should follow the field investigation, but in the meantime the technical details of such an investigation, with special relation to the required blank, etc., would receive consideration. As to the best possible blank for the purpose, it was agreed that the chairman should have such a blank prepared on the basis of previous investigations in this country and abroad, and Dr. Lanza promised to furnish copies of the blanks used by him in the examination of some 1,500 miners in the Butte (Mont.) district.

Dr. McMichael agreed to report possible individual cases of lung fibrosis and pulmonary tuberculosis obviously in consequence of dust exposure, although he felt somewhat doubtful as to the amount of material likely to present itself in his section of North Carolina in view of the limited extent of the dusty trades in that portion of the country. He, however, further agreed to undertake whatever duties might be assigned to him in connection with the more highly involved technical aspects of the inquiry, particularly as to pathological phases, and perhaps autopsy records, etc.

Dr. Baldwin then directed attention to the fact that a limited amount of animal experimentation was being carried on at his laboratory, limited for the time being to exposure, under control, of guinea pigs to finely comminuted granite dust. He hopes later to carry on similar experiments with marble dust, and the chairman agreed to obtain for him a sufficient quantity of limestone dust for the same purpose. He explained that three forms of experiments were carried on—first, with animals in thorough health and not heretofore exposed to tuberculosis; second, with animals suffering from slight tuberculosis infection; and third, with animals infected with tuberculosis subsequent to prolonged dust exposure.

The order of procedure in the proposed investigation was then agreed upon more or less as follows:

1. The preparation of a brief outline of the general subject, limited to the stone industries of the State of Vermont, by the chairman, possibly amplified by a preliminary personal investigation of the conditions in the territory, with conclusions useful for the guidance of the field workers.
2. A qualified preliminary technical investigation of industrial conditions and industrial processes in the granite and marble industries of the State of Vermont by the chairman and one of his office assistants through the cooperation of the Prudential. This study would include a descriptive account of the most injurious or dust-producing industrial processes, with illustrations of the tools used, etc. This investigation would probably be made by Mr. Edwin E. A. Fisher.
3. The chairman agreed to take steps to ascertain, through the cooperation of the State Board of Health, the best method by which a transcript might be had or a reanalysis might be made, of the death certificates of stoneworkers in certain selected towns of the State of Vermont. If it should be found impossible for the State Board of Health on account of limited office force to assist in the required statistical work, the chairman intimated the probability that the Prudential would assume the expense of such an investigation, aside from the company's willingness to assume the expense of printing the required blanks for the general conduct of the field investigations and the physical examinations subsequent thereto.
4. The so-called house-to-house investigation should, as far as practicable, be under the direction and control of the State Board of Health of Vermont. It should proceed

in conformity to the best examples of corresponding investigations in this country and abroad, and the data, as far as practicable, should be made comparable with other investigations so as to enhance their value for future use.

5. The more involved technical investigation of the industry should be jointly under the direction of the United States Public Health Service and the United States Bureau of Mines, corresponding, as far as practicable, to the investigations made by these two Government departments into the relation of siliceous dust to pulmonary disease among miners in the Joplin district in Missouri. It was agreed that the chairman should frame a resolution for adoption by the executive committee of the National Tuberculosis Association suggesting the official cooperation of the director of the United States Bureau of Mines and the Surgeon General of the United States Public Health Service, corresponding to a similar resolution transmitted under date of May, 1911, and which resulted in the undertaking of the investigation previously referred to.

6. The physical examination of employees, and possibly members of their families, should, if any way practicable, be under at least the direction of the United States Public Health Service, in affiliation, however, with such other official and voluntary agencies as might be secured to enlarge the field of inquiry and to improve the quality of the results.

7. The X-ray examinations should be made locally but in cooperation with the Trudeau Foundation, the State sanatorium, and the local hospitals in the districts concerned.

8. Post-mortem examinations should be obtained in a sufficiently large number, possibly on the basis of a ruling of the State Board of Health, concerning the modification of doubtful death certificates.

9. The problem of domestic infection, or more precisely, the incidence of tuberculosis among the wives and children of stoneworkers, should be made a matter of separate inquiry, so as to avoid confusion with the main purpose of the investigation, having primarily and practically exclusively to do with the health-injurious consequences of continuous and considerable dust inhalation in the stone industries of the State. It was agreed, however, that, as far as practicable, the entire family should be included in the personal examination.

10. The problem of prevention obviously could not receive consideration until the entire new material had been properly assembled and made the subject matter of qualified discussions and of definite recommendations.

11. Finally, the proper care of incipient cases, and possibly the still more involved question of workmen's compensation for fibroid lung diseases contracted in the course and in consequence of the employment were left open for future consideration.

Aside from the foregoing, it was agreed that, as far as practicable, the slate and talc industries of Vermont should be brought within the plan and scope of the investigation, although apparently limited to the health-injurious consequences of granite and marble dusts.

The question of the pottery industry, and that of dust exposure in flint mills, was left for consideration at a subsequent meeting, but the chairman agreed to make tentative inquiries into the subject.

Dr. Caverly directed special attention to dust-producing processes in the slate industry in Rutland County, and the generation of vast quantities of dust, sufficient to prove at least obnoxious to the surrounding country, and resulting in lawsuits on the ground of damage done to vegetation, etc.

The committee then closed the discussion concerning the granite and marble industries and took up the question of the limestone industries of Southern Indiana, which will be dealt with in a subsequent report.

Very truly, yours,

FREDERICK L. HOFFMAN,
Chairman Committee on Mortality from Tuberculosis in Dusty Trades.

In a second communication dated July 25, 1918, the report upon the conference to the president of the association was completed.

Dr. David R. Lyman,

President National Tuberculosis Association, Wallingford, Conn.

Dear Dr. Lyman: After having fully agreed upon the details of the proposed investigation of the stone industry in the State of Vermont, the committee took up the question of a corresponding though possibly less extensive investigation into the dust problem of the limestone industries of southern Indiana. The chairman presented the results of a fairly extended correspondence with the secretary of the Bedford Stone Club Auxiliary of Bedford, Ind., and some statistical data conveying an urgent suggestion for a thorough inquiry into local conditions, briefly set forth as follows:

In consequence of a controversy involving the use of the pneumatic tools in stonecutting, etc., and the alleged mechanical injuries to the hands and arms, all of which has been made the subject of exhaustive investigations by representatives of the industry, the labor union, the Federal Bureau of Labor Statistics, the United States Public Health Service, etc., the question had incidentally been raised as to the possible injuriousness of pneumatic tools on account of the large quantities of fine dust raised during the mechanical operations. The viewpoint, however, had been advanced by the secretary of the Bedford Stone Club Auxiliary that "Tuberculosis unquestionably is far more prevalent in the granite and sandstone industries than in the Indiana limestone industry. Not only are our accommodations more modern than generally found elsewhere, but the nature of the stone itself is such as to preclude most of the detrimental elements which are a source of objection in other sections of the business. Indiana limestone, as commonly worked, is moist, in fact, one may say, wet. Furthermore, its physical make-up is such as to cause an almost total absence of sharp, gritty particles which, according to my (Dr. Richter's) understanding, are the chief objection in granite and sandstone."

Dr. Richter referred also to the report of Dr. Barnes, of St. Louis, and subsequent investigations by Dr. Leake, of the Public Health Service, and Dr. Edsall, the well-known authority on occupational diseases, to the effect that "They are unanimous in their finding that the prevalence of dust in the mills of the Indiana limestone district is negligible factor. This because the stone as worked here is drenched with water at various stages of fabrication, which water is not evaporated to any extent until the stone is practically ready for loading."

"These doctors have further agreed that the general health of all the stonecutters examined and interviewed here is exceptionally good and that without question or doubt they rate much higher in that regard than stonecutters generally."

Assuming for the time being that these conclusions are correct, it would nevertheless be of the first importance to ascertain with the required degree of thoroughness and scientific accuracy the facts, more or less in the manner as has been done so admirably by the United States Bureau of Mines in their recent report on Siliceous Dusts in Relation to Pulmonary Diseases among Miners in the Joplin District, Missouri. The committee therefore agree that in view of the most hearty and unqualified assurances of active cooperation on the part of the Bedford stone industry the entire subject matter should be taken up with reference to the limestone industry of southern Indiana. It, however, was clearly recognized that the strictly technical phases of the investigation would probably have to be taken care of by the United States Bureau of Mines and the United States Public Health Service.

As a matter of record the chairman read from a letter addressed to him by the secretary of the Bedford Stone Club Auxiliary, dated January 19, 1918, reading in part:

"It seems to us, therefore, that the matter to which we refer hereinbefore must be of vital interest to you. Our interest in it is twofold. We want to show in all fairness that the effects of the pneumatic tool are not such as to warrant discrimination. We want further to create for our workmen a condition which will give them every benefit so far as insurance, among other things, is concerned, which may rightly accrue from the fact, first, that the pneumatic tool does not imply hazard, and, second, that in our operations in Indiana tuberculosis owing to dust is practically, if not entirely, an unknown experience."

It having been agreed that such an investigation should be undertaken, it was thought best, however, to postpone the work in Indiana until the plan of inquiry had been thoroughly worked out for Vermont. The chairman was able to inform the committee that assurances had come to him from the State health officer of Indiana that the Board of Health of that State would most heartily cooperate, and that in addition a corresponding offer of cooperation had also been forthcoming from the general office of the Journeymen Stonecutters' Association, Mr. Walter W. Drayer, general secretary, Indianapolis. Mr. Drayer's letter concludes with the statement which is here incorporated as a matter of record, that he is "only too pleased to assist you in any way possible in your investigation of health conditions in the stone trade of Indiana."

Dr. Alice Hamilton reported briefly upon her own investigations in Indiana, almost exclusively, however, with reference to the alleged injurious mechanical effects of pneumatic tools, with which, of course, the committee on dusty trades has no direct concern. She gave the assurance of her entire willingness to cooperate to the fullest extent and it is to be hoped that this may be feasible through the United States Bureau of Labor Statistics. Dr. Hamilton's experience, it was clearly recognized, would be invaluable to the committee, more so in view of the fact that she had also made personal investigations in connection with these matters in Vermont.

Before concluding its session the committee considered, briefly, the problem of metallic dust, as observed in connection with the military industries of the Government. Dr. Lanza intimated that some useful information would probably be forthcoming in consequence of his investigations of conditions at the plants of the Winchester Arms Co.

Dr. Baldwin explained briefly his laboratory experiments with guinea pigs exposed intermittently to the inhalation of granite dust, which, however, had not proceeded sufficiently far to justify definite conclusions. The committee were shown over the laboratory and gained much useful knowledge. Dr. Baldwin incidentally brought up the question of the health injuriousness of the dust inhaled by the workmen employed in the carborundum plants at Niagara Falls. When he had first visited this plant some years ago, he had been assured of the practically noninjuriousness of the dust, regardless of the obvious and perceptible evidence to the contrary. Subsequently a number of the employees from this plant had come to Saranac Lake suffering from tuberculosis, and, although the evidence, of course, was not final as to whether the disease had been contracted in consequence of the exposure to carborundum, a general conclusion to this effect seems justified in view of the conditions observed. It was therefore agreed that if the executive committee of the National Tuberculosis Committee should meet as intended at Buffalo, in August, the committee on dusty trades would meet jointly and perhaps take up a brief investigation into the conditions at Niagara Falls in the plants referred to. Dr. Baldwin assured the committee that Dr. Bowman, in charge of the welfare work and himself a sufferer from tuberculosis in the incipient stage of the disease, would no doubt cooperate in the fullest extent.

The committee thereupon adjourned subject to the call of the chairman.

Very truly, yours,

FREDERICK L. HOFFMAN,
Chairman Committee on Mortality from Tuberculosis in Dusty Trades,
National Tuberculosis Association.

On the occasion of the meeting of the executive committee preceding the meeting of the special committee a resolution had been introduced by the chairman of the committee, and had been unanimously approved, as follows:

RESOLUTION UNANIMOUSLY ADOPTED AT THE MEETING OF THE EXECUTIVE COMMITTEE OF THE NATIONAL TUBERCULOSIS ASSOCIATION.

Whereas the special committee on the scientific study of the dusty trades in their relation to the relative frequency of tuberculous diseases have unanimously agreed to concentrate their efforts for the time being upon the morbidity and mortality of men employed in the stone industry of the State of Vermont and the limestone industry of the State of Indiana; and

Whereas, in the furtherance of their work, the committee are most urgently in need of governmental cooperation in certain highly specialized matters of field inquiries and laboratory research; be it therefore

Resolved, That the United States Public Health Service and the United States Bureau of Mines be requested to undertake jointly a thorough investigation of the dust problem in the stone industry of Vermont and Indiana, with a view to the ascertainment of all the facts having a bearing upon the excessive incidence of tuberculous and nontuberculous respiratory diseases in the several branches of the industries referred to, and the determination of the best possible methods and means whereby the morbidity and mortality of the men employed therein may be materially reduced by the adoption of more effective safeguards and improved methods of sanitation than those in use at the present time.

Assured of the hearty cooperation of the Vermont State Board of Health, the efforts of the chairman were concentrated upon the Vermont stone industry as the most promising line of research during the summer and early fall. Of interest and value is therefore a letter from the secretary of the board, Dr. Charles F. Dalton, dated July 22, 1918, reading as follows:

Under separate cover, I am sending you a rough model of a granite cutter's hand tool for combining pneumatic suction with compressed air. The principle of this tool is that a circular jacket is placed around the shaft of the tool which is either square or several sided, leaving a space through which the granite dust can be withdrawn. The working of this tool would require a hose for suction as well as the pressure hose and, as this would materially add to the weight, it has been objected to on this ground by some granite workers who have seen it. However, I am informed that this tool which I am sending you has actually been used and demonstrated that it will do the work if some difficulties can be overcome. This model was made by Mr. Allan Calhoun, formerly factory inspector for the State of Vermont, but he has turned it over to the State Board of Health for such use as can be made of it.

I have personally gone over the matter of the use of a hand tool with representatives of the granite manufacturers in Barre and also with the granite cutters. They are apparently ready and willing to adopt any feasible plan for the elimination of granite dust from hand tools, but at my last conference with them they did not know of any practical method of accomplishing this result.

All this is at the suggestion of Dr. Caverly, who tells me that you are likely to come to Vermont some time in the near future to visit the Barre granite industries. I shall be glad to accompany you on the trip and am much gratified that this work is being taken up.

This letter was amplified by a subsequent communication dated July 27, 1918, which is also given in its entirety:

Your letter addressed to me in Montpelier has just reached me via Burlington. You speak in your letter of the desirability of our board assisting at least in the house-to-house inquiry that will be made into the stonecutting industries of Vermont, as a result of our conference at Saranac Lake. I know that our board will be in entire sympathy with this work. However, at the present time, by reason of resignations, due to war work and other things, we are crippled. We have no inspector just now, but I have no doubt the executive secretary of the State Tuberculosis Association, who works under the auspices of our board part of the time, may be utilized for some inquiries in this work. We shall have, I hope, an inspector soon. If you can defer the investigation for a month or two I think we should be able to give you more assistance. The matter will be brought to the attention of the board at its next monthly meeting, which occurs August 8, and you will be notified more specifically of the extent of cooperation which may be expected from us. You are perfectly right in thinking that the board will furnish you every assistance possible in this work, in which we are all very much interested, the importance of which has been recognized by us for a great while.

There is included also a statement presented by Dr. Caverly at the Saranac Lake meeting of the committee, which will be found useful for future reference:

Number of granite cutters in the Barre district (comprising about 6 towns), 3,000.

Number of helpers, 1,000.

Number of men in quarries, 1,000.

Barre City, with a population in 1910 of 10,784, had 135 deaths from all causes; 28, or 20.7 per cent, were from tuberculosis of the lungs; 33, or 24.4 per cent of these deaths were from tuberculosis in some form.

Number of deaths from tuberculosis of the lungs in the State runs in recent years from 250 to 300, hence the number of deaths in the city of Barre is approximately 10 per cent of all that occurred in the State.

Number of admissions at the State sanatorium for incipient tuberculosis since it was opened, 10½ years ago, of granite cutters, quarrymen, and granite workers has been 56 out of a total number of admissions of 963, or 5.8 per cent.

Barre Town, which is a township surrounding the city, with a population of 419, had 4 deaths from tuberculosis in 1917, out of a total number of deaths of 51.

Montpelier City, with a population of 7,856, had 13 deaths from tuberculosis of the lungs in 1917, with total deaths of 121. Pulmonary tuberculosis rate is 10.7 of the total deaths.

Number of admissions to the sanatorium among marble tracers, graders, polishers, cutters, and workers since institution opened, 10. Number of slate quarrymen and cutters, 7.

The marble and slate industries are centered in Rutland County.

The secretary of the Granite Manufacturer's Association is Mr. Hinman, of Barre City. Dr. Alice Hamilton, of Chicago, has recently made an investigation of the granite indutry for the Department of Labor at Washington.

As bearing upon the more general work of the committee, there is included here a letter from the director and chief engineer of the division of sanitary engineering of the State Department of Health of West Virginia, Mr. Mayo Tolman, dated August 2, 1918:

FREDERICK L. HOFFMAN,
Third Vice President and Statistician, Prudential Insurance Co.,
Newark, N. J.

DEAR SIR: I was deeply appreciative to receive your kind letter of recent date in reference to my "Sanitary survey of Charleston." This was particularly the case as not only has the report not received any comment in this city but has failed to awaken the slightest interest, so deeply set has Charleston become in the rut she has traveled for years.

I am sorry that I can not report more definitely upon the tuberculosis condition at the Kelly Ax Works. The works have been investigated on six different occasions by the State Department of Health, on several other occasions by Miss Erma Slack, the nurse of the Anti-Tuberculosis League, and all investigators report that the deaths among ax grinders have accurred among those men who are known to have been infected before the installation of dust removal machines. However, Dr. Holt Barksdale, one of the leading younger physicians in Charleston and a man who has made a special study of tuberculosis in Charleston, is of the opinion that the ax plant is still responsible for much tuberculosis in Charleston. Living conditions in the vicinity of the ax works are as noted in the report, deplorable, and there are well authenticated cases where men who appeared perfectly well have used the same bed with advanced cases of tuberculosis and it would seem possible that the disease has been spread in this fashion. My own experience with the ax plant shows that the dust removers are not given sufficient attention to make them fully effective at all times. I think the illustration in the report will prove this for sparks can be seen flying well towards the ceiling.

Again thanking you for your kindness in commenting on this report, I remain,
Most sincerely, yours,

MAYO TOLMAN,
Chief Engineer, State Department of Health.

There is also included a letter from Dr. H. R. M. Landis, of the Henry Phipps Institute, bearing more directly upon the question of proper blanks and forms to be used in connection with the proposed investigation in the State of Vermont.

I quite agree with you that many of the blanks used in these investigations are too much overloaded with detail. I have Lanza's report and I think you might as well follow that. I do feel, however, that much more extensive study of the outside life of the men is needed than is contained in this industrial investigation with the one exception of the study made by Mrs. Lit and myself. For example, I saw a potter yesterday who acquired a slight tubercular infection in addition to his dust disease and made a perfect recovery and returned to his trade as a potter. He remained perfectly well for a year and a half and then broke down as a result of starting drinking. I cite this simply to draw attention to the fact that it is necessary to know how and where these men live before I am convinced that their method of living has as much influence, if not more influence, as has the evils of their employment. I feel that any investigation such as you are about to make should result in a very incomplete study if it fails to cover this phase of the subject. It should not be very difficult to get a good family history, seeing the presence or absence of tuberculosis in the family, the general hygienic condition of the home and the neighborhood, and the present habits as to food, hours of sleep, and indulgence in alcohol.

On account of prolonged absence from office in connection with an extended western trip, the chairman found it impossible to undertake the proposed investigation in Vermont, but assigned the subject to one of his office assistants, Mr. Sylvester Schattschneider, with extended experience in field investigations of this kind.

The outbreak of the influenza epidemic occurred at just about the time when the field investigation was to have been commenced, and the same had therefore to be abandoned for the time being.

Still more lamentable was the untimely death of Dr. Caverly, president of the State Board of Health of Vermont, to whose active cooperation, high scientific attainments, and always hopeful attitude of mind, the chairman and the committee are under lasting obligation.

Partly, as stated, on account of prolonged absence from office, but also on account of the influenza epidemic, etc., no subsequent meetings of the committee were held. It is hoped, however, that a meeting can be arranged for in the near future; but frequent conferences have been had on the part of the chairman with members of the committee concerning matters of detail.

b. SGU
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